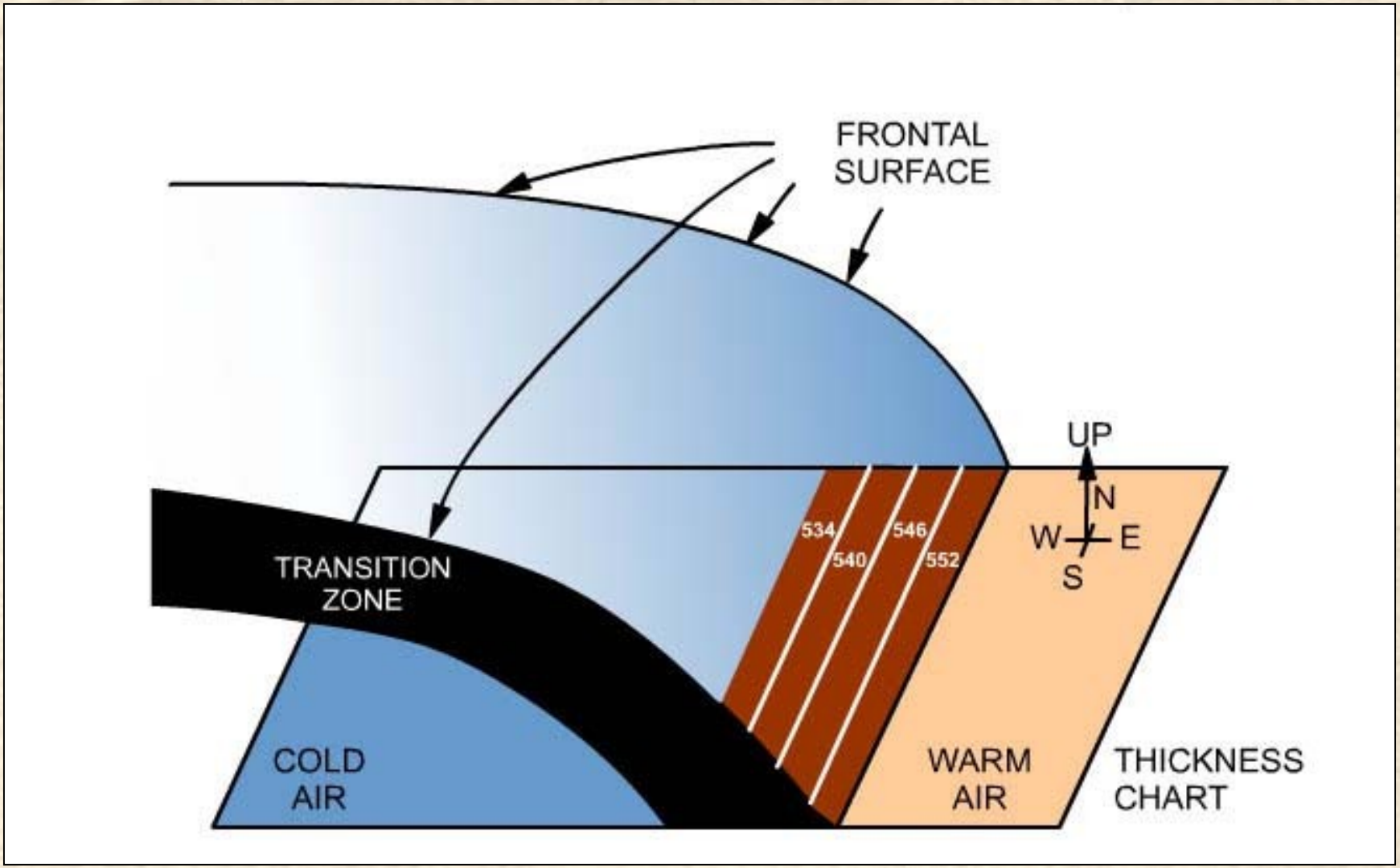
Atmospheric Dynamics II

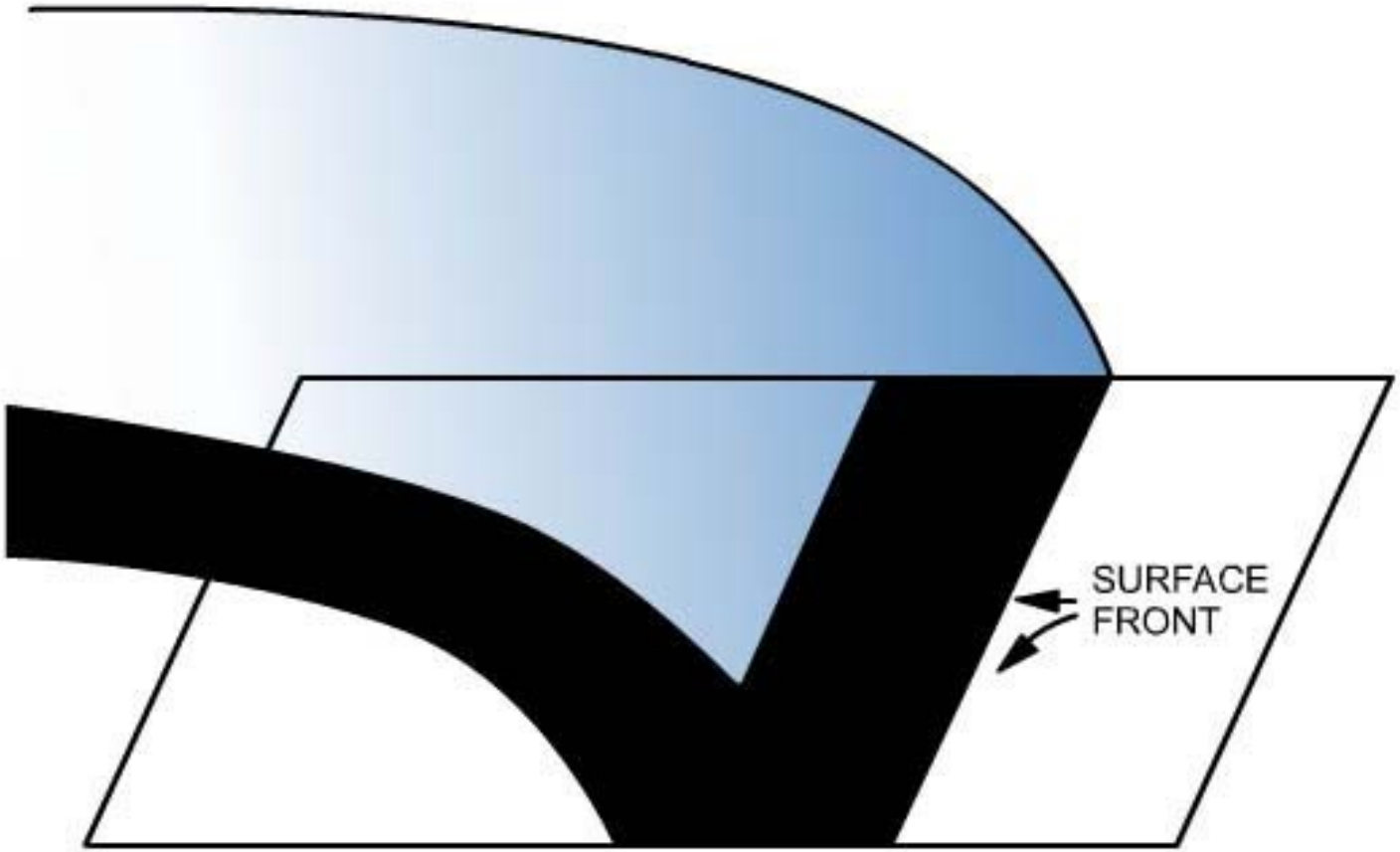
Determine the properties of the frontal system indicated.

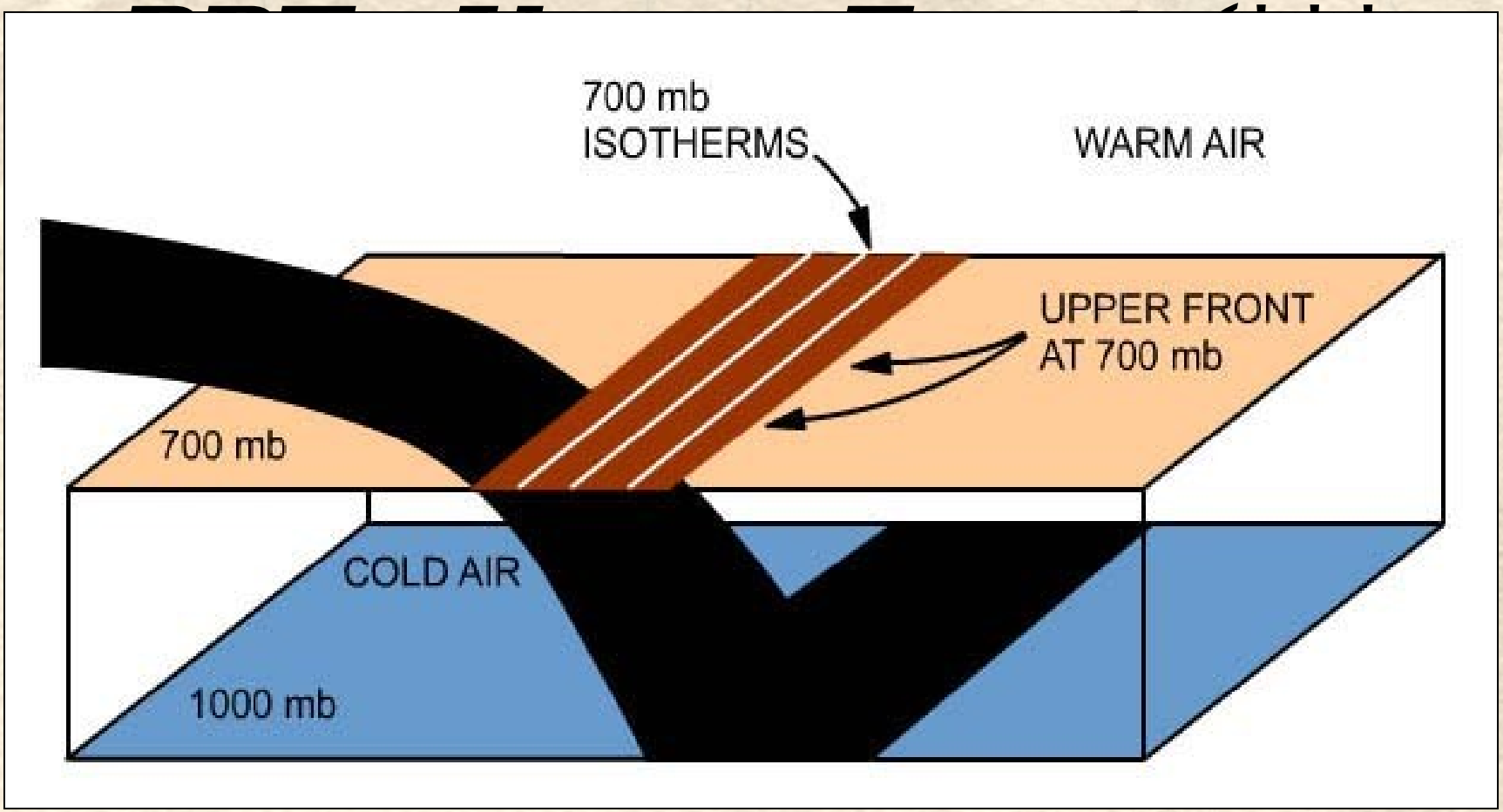
Frontal System Terminology

- Frontal Surface - Boundary separating two air masses along which a distinct contrast in temperature, moisture, and wind exist within a trough of lower pressure.

- Surface Front - Intersection of frontal surface and the ground.

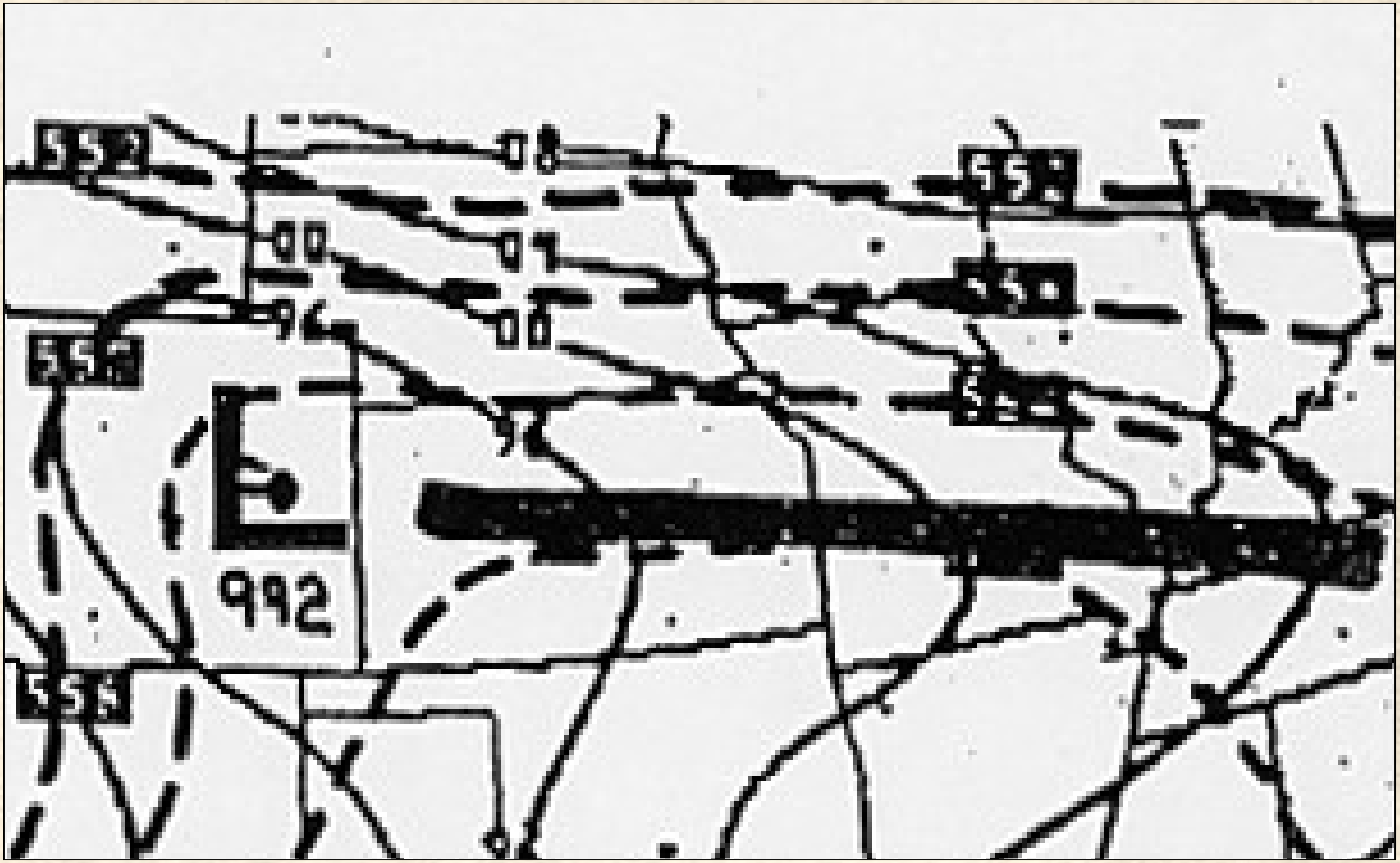

FRONTAL
SURFACE
UP
N
W
E
S
534
540
546
552
TRANSITION
ZONE
COLD
AIR
WARM
AIR
THICKNESS
CHART


SURFACE
FRONT


700 mb
ISOTHERMS
WARM AIR
UPPER FRONT
AT 700 mb
700 mb
COLD AIR
1000 mb

Frontal System Terminology

- Upper Front - A frontal surface aloft.
- Boundary - Feature which separates two air masses.
- Frontal Trough - A trough (i.e., cyclonic curvature) in height contours or isobars which is coincident with frontal surface.

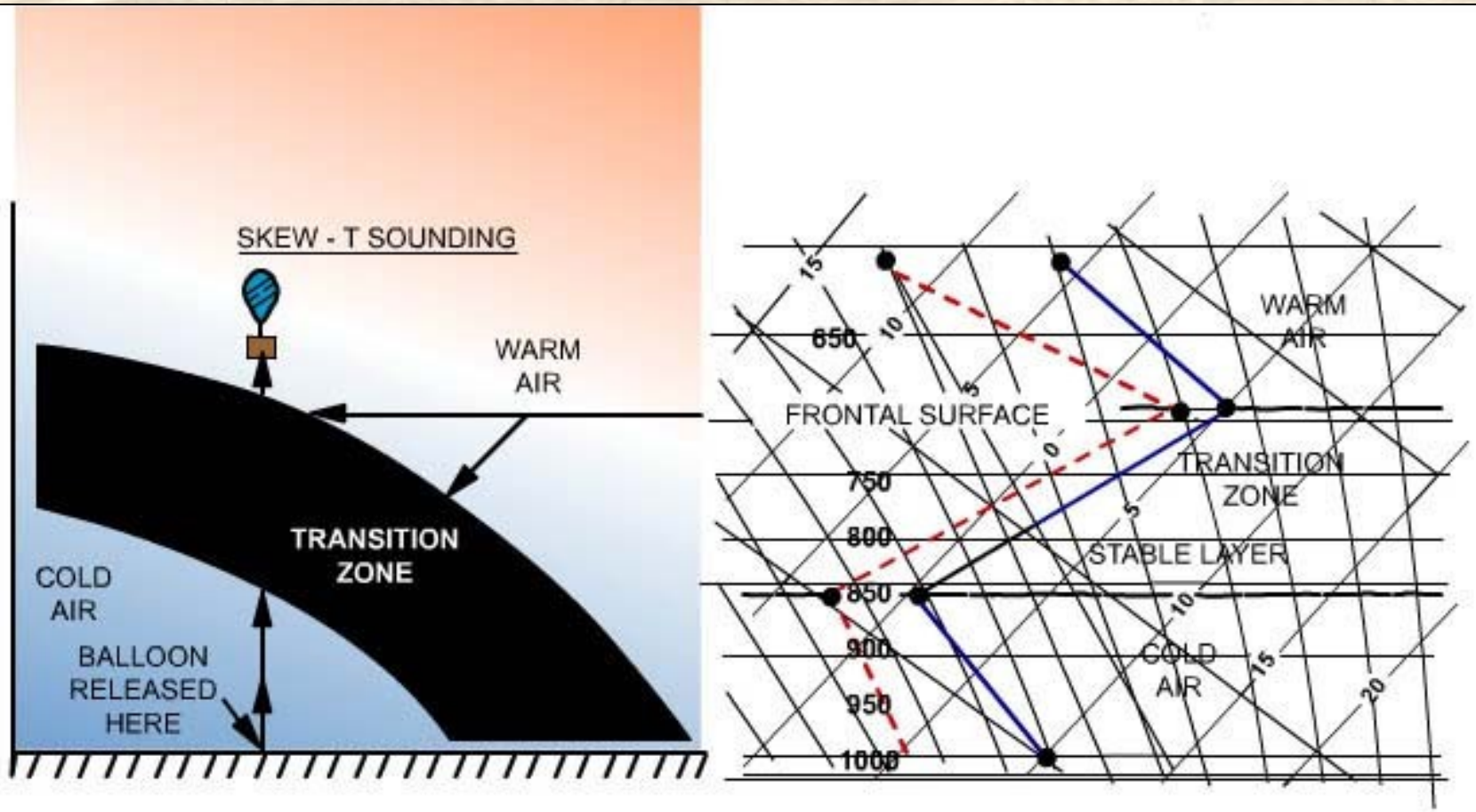

552
558
550
992
553

Frontal System Terminology

- Stable Layer - Region with negative, isothermal or weak positive lapse rate on skew-T where transition from colder air mass to warmer air mass takes place.
  - Commonly referred to as frontal inversion
  - Below layer is within colder air mass
  - Above layer is within warmer air mass

Frontal System Terminology

- Moisture Characteristics - dew-point curve usually follows temperature curve and shows moisture increase with height through the inversion. Thus, the frontal inversion is usually very moist, and saturation / cloudiness is common.


SKEW - T SOUNDING
WARM AIR
TRANSITION ZONE
COLD AIR
BALLOON RELEASED HERE
FRONTAL SURFACE
WARM AIR
TRANSITION ZONE
STABLE LAYER
COLD AIR
650
750
800
850
900
950
1000
15
10
5
0
5
10
15
20

Frontal System Terminology

- Frontal Movement - The movement of a front is strongly influenced by
  - Jet stream forcing and short-wave trough motion in the upper troposphere

Frontal System Terminology

- The magnitude and orientation of wind flow with respect to frontal zone.
  - Mid-tropospheric (500 mb) wind.
    - Parallel to front
      - » stationary or slow motion
    - Perpendicular to front
      - » faster motion

Frontal System Terminology

- Component of wind 850-700 mb flow within the cold air.
  - Parallel to front
    - » stationary or slow motion
  - Perpendicular to front
    - » faster motion

Frontal System Terminology

- Orientation and magnitude of the surface wind relative to the front
  - Wind on cold side has larger perpendicular magnitude than on the warm side.
    - » usually indicates the front will move toward the warmer air
  - Wind on warm side has larger perpendicular magnitude than on the cold side.
    - » usually indicates the front will move toward colder air

Frontal System Terminology

- Significant density differences between air masses
  - Much denser air (i.e., cA air) will tend to “spread” in the direction of less dense air (i.e., mT air), forcing the frontal boundary to move toward the less-dense air.

Frontal System Terminology

– Terrain.

Terrain can have a significant impact on frontal motion near the surface.

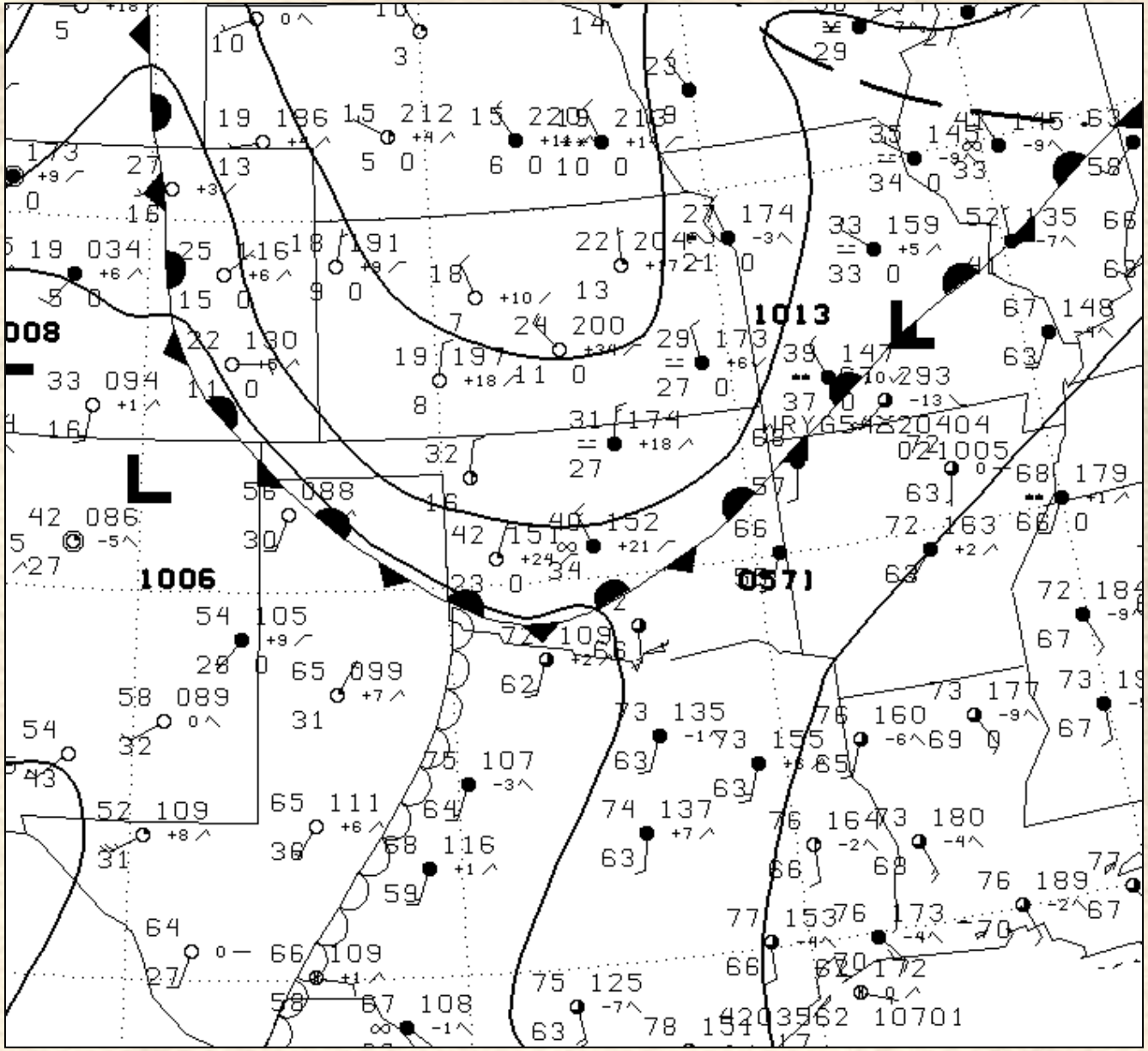
- Mountains may cause damming of cold air, which will alter the motion of the front.

Frontal System Terminology

- For deeper fronts, the surface front may be prevented from moving over the mountain range and is left behind as the upper-level front proceeds unobstructed. This behavior is common near mountains oriented perpendicular to the jet stream, such as along the mid-latitude Pacific Coasts of North and South America.

Frontal System Terminology

- Variations in surface temperature and moisture characteristics can have some effects on the apparent motion of fronts, particularly if major modifications of the air masses on either side of the front occurs. This is more likely with slow moving or stationary fronts and rather “shallow” air masses.
  - Example: A stationary front may reside over the warm Gulf of Mexico 100 miles south of the MS/AL Coast. Shallow cold dry air north of the front may experience dramatic modification over the warm water, thereby forcing the front to “reform” directly along the coast. This reformation (I.e. frontogenesis) of the front is not actually due to the front moving, but the front has changed position just the same.


1013
1006
0571
L
L

Frontal System Terminology

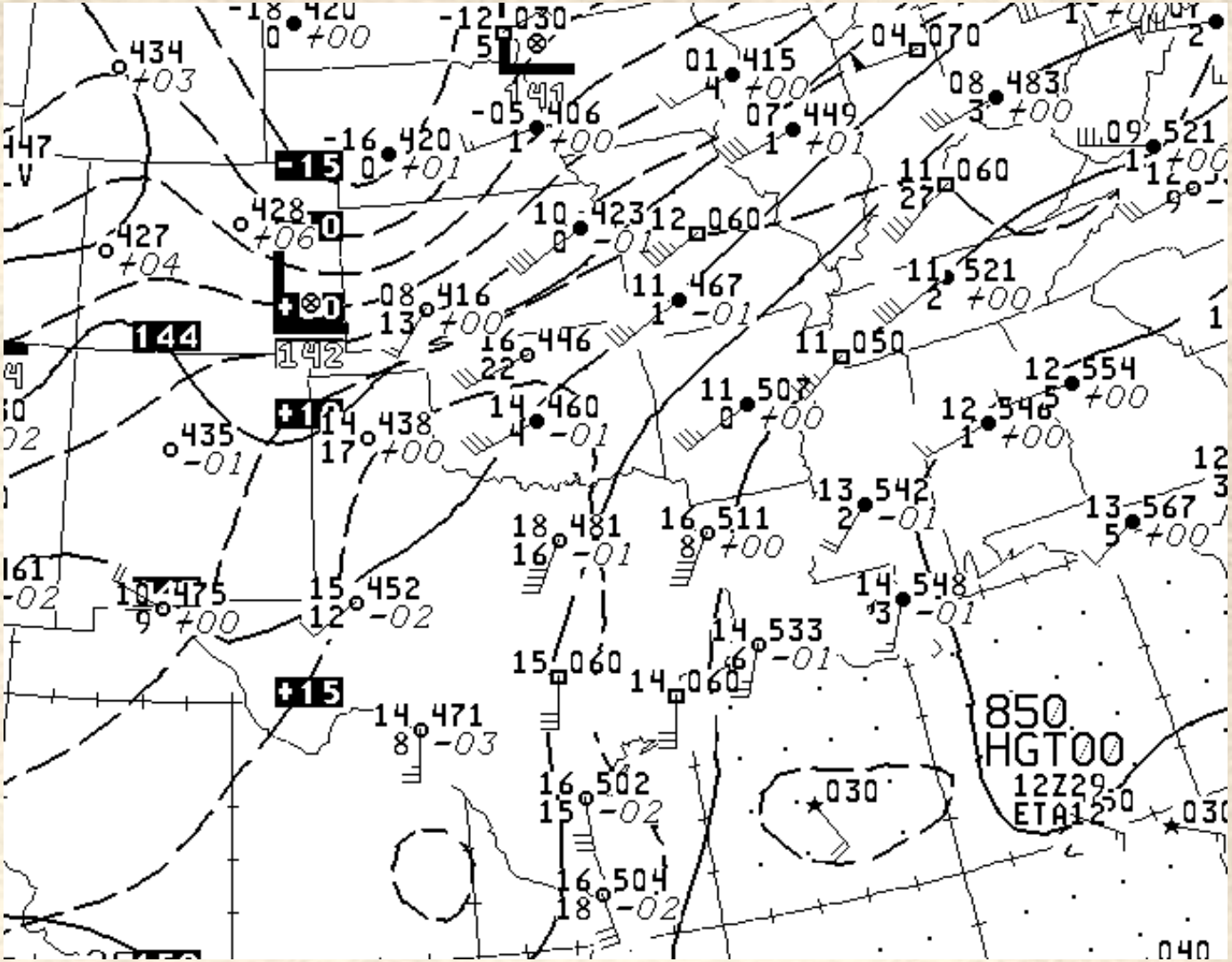
- In the surface analysis above, the front is not moving in northern Texas and Oklahoma.
- At first glance the front should be moving south because of::
  - The extreme density difference between the dense cA air to the north and less dense mT air to the south.
  - The greater perpendicular “ageostrophic” wind component on the cold side of the front

Frontal System Terminology

- The strong pressure rises of over 2 mb just north of the front in OK compared to only small pressure changes of <0.5 mb south of the front in TX.
- Cold air damming in easterly “geostrophic flow” against the Rockies north of the front.
- Indeed, if this was the only chart available, a weather forecaster might expect this front to move southward… but they would be WRONG!

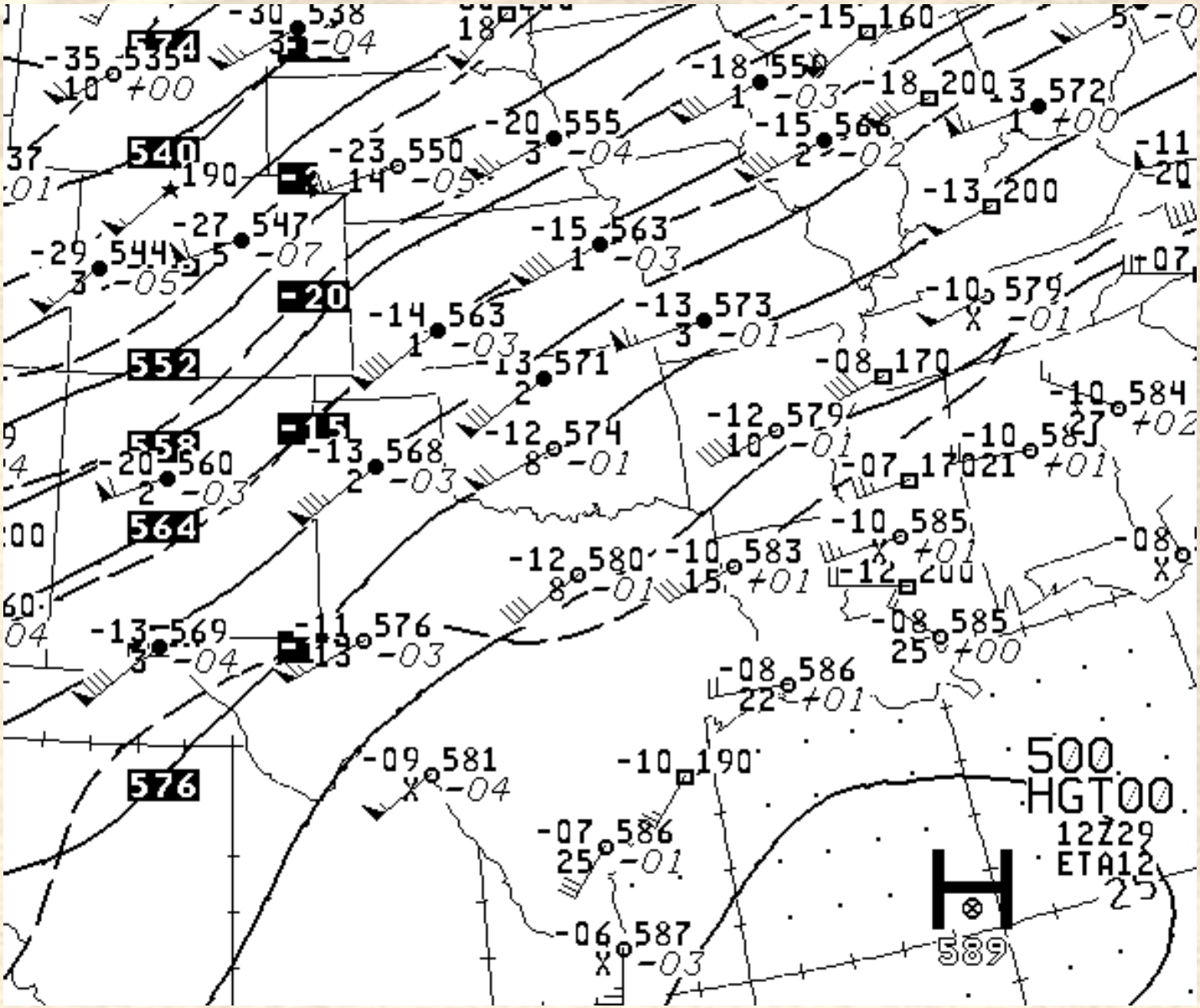
Frontal System Terminology

- In this case, (as with many other situations) the key lies in the upper levels above the surface. All the processes above the surface are opposing the southward movement of the front.


850
HGT00
12Z29
ETA12

Frontal System Terminology

- At 850 mb:
  - The 850 mb front is located much farther to the north in IA, NE, KS, and CO (i.e., the frontal slope is very shallow [discussed below]) with strong warm advection “overrunning” (discussed later) occurring over OK and northern TX.
  - An 850 mb low level jet of 40 knots is nearly directly opposing any southward movement of the front at lower levels in TX and OK.


500
HGT00
12Z29
ETA12
25
589

Frontal System Terminology

- At 500 mb:
  - Brisk southwesterly flow dominates the Plains, indicating a trough may be approaching from the west.
  - Extensive height falls are observed throughout the Plains from Texas through the Dakotas, again indicating that a trough is approaching from the west.
  - Indeed, a MAJOR upper-level trough is approaching from the west, which indicates that warm advection, upper-level divergence, and surface pressure falls should all help erode the cold high pressure ridge north of the front and help prevent the front from moving further south.

Frontal System Terminology

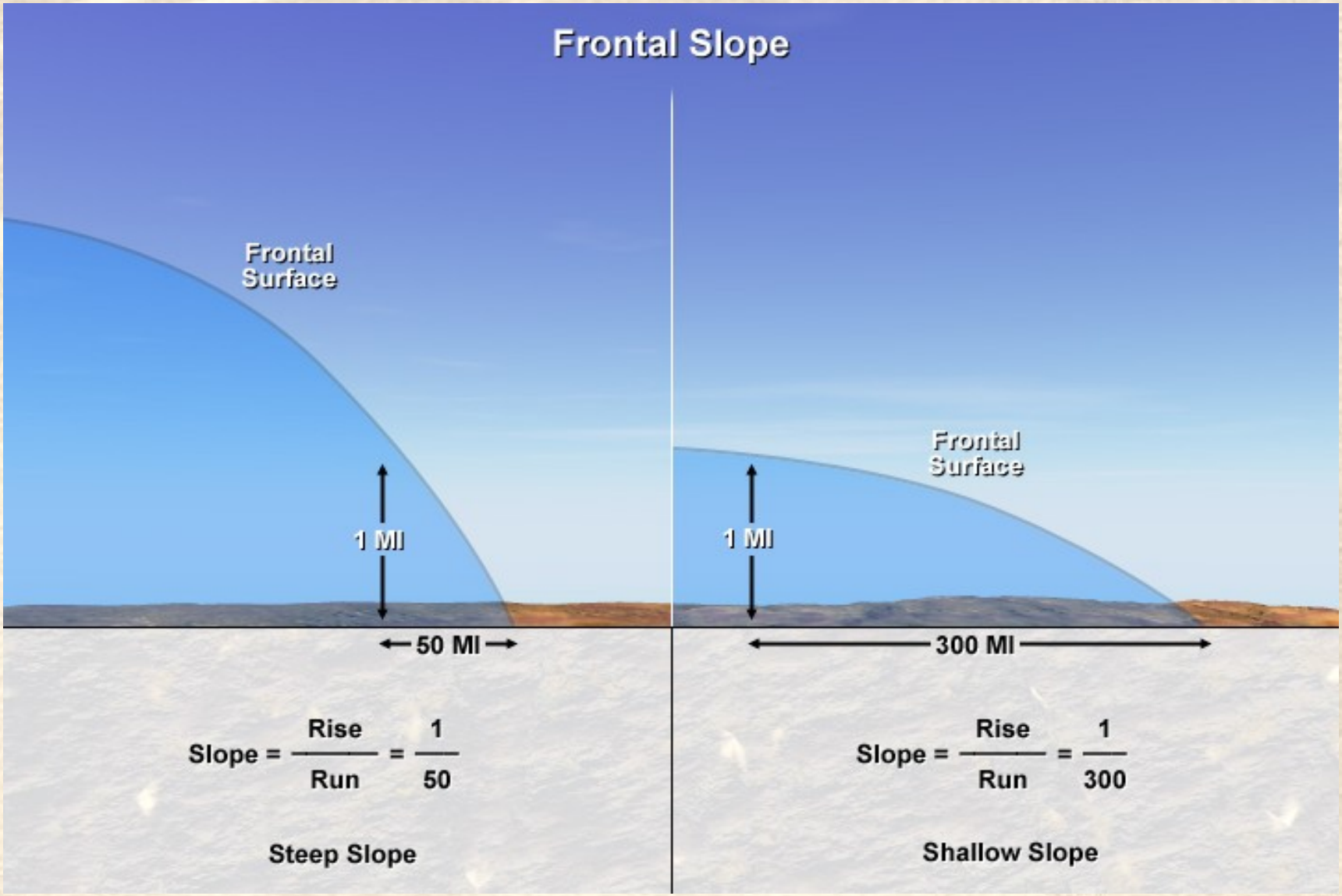
- In this case, there there is a stalemate between southward and northward directed forces influencing the frontal motion. Therefore, the front is stationary.

Frontal System Terminology

- Frontal Slope - Slope = RISE/RUN. Rise is the vertical distance to the upper front and run is the horizontal distance to surface front.
  - Frontal slope represents a potential lifting mechanism for the warmer air in the frontal zone. ACTUAL lift depends on numerous factors, such as the amount of wind convergence along the front, jet stream divergence aloft, stability and advection of the warmer air, and topography.

Frontal System Terminology

- Although air may initially be lifted by the front, it rarely ascends the entire vertical length of the frontal surface. Latent heating of condensation, instability, and other factors often allow the air parcel to rise at a steeper slope than the actual frontal slope would indicate.
- Fronts fairly close to their jet stream/upper-level trough locations tend to have steeper slopes than those farther away from the jet stream/upper-level trough, but frontal slope does not indicate how strong or weak the lifting of air may be.


Frontal Slope
Frontal Surface
1 MI
50 MI
Slope = Rise / Run = 1 / 50
Steep Slope
Frontal Surface
1 MI
300 MI
Slope = Rise / Run = 1 / 300
Shallow Slope

THE SLOPE SHOWN BELOW IS $\frac{1}{50}$ A FRONT WITH THIS SLOPE WOULD BE CONSIDERED STEEP!!

Frontal System Terminology

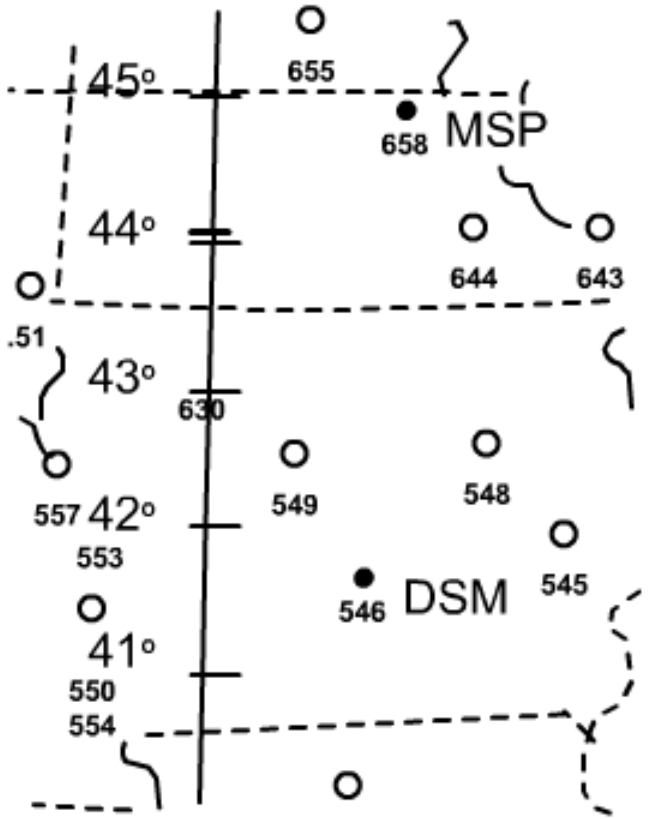
- Determination of Frontal Slope.
  - Vertical distance (RISE) - when measuring height of frontal surface, several approximations are used.
    - 5000 ft = about 1 mile
    - Wherever terrain is near sea level, 850 mb level is about 1 mile high.
    - In elevated regions, the 850-mb level is close to the surface and 700-mb is about 1 mile high.
  - Horizontal Distance (RUN) - when measuring horizontal distance from the surface front to location beneath upper front, several approximations are used.

  NOTE: 1 degree of latitude = 60nm.

Frontal System Terminology

- NOTE: The distance from the NW corner of Kansas to the NE corner of Colorado is 1 degree of latitude. Use this as a reference distance on CONUS maps.
- IMPORTANT: NUMBER OF DEGREES OF "RUN" ESTIMATED AT THE SAME LATITUDE THAT THE MEASUREMENT WAS TAKEN.

FIND THE DISTANCE BETWEEN MSP & DSM



MSP: 45ºN
DSM: 41.5ºn

DISTANCE=
45º - 41.5º = 3.5º
3.5º X 60 $\frac{nm}{deg}$ 210nm

Frontal System Terminology

- Shallow-sloped Fronts:
  - Warm advection “over-running” is favored (but not guaranteed).
    - Remember from Dynamics I that the Omega Equation indicates that warm advection is a lifting mechanism.
  - If jet-stream divergence and/or warm advection “over-running” above the frontal surface is strong, extensive shields of precipitation may extend from the surface front for large distances over the colder air.
    - This type of situation most often occurs with warm and stationary fronts.

Frontal System Terminology

- If jet-stream divergence and/or warm advection “over-running” is weak or non-existent above the frontal surface, precipitation may be totally absent or confined to a very narrow band near the surface front.
  - This type of situation is most likely with a cold or stationary front which resides well equatorward of the jet stream.

Frontal System Terminology

- Steeply-sloped Fronts
  - Warm advection “over-running” is not favored, or is of very limited extent.
  - In the presence of strong jet-stream divergence, rather narrow but heavy areas of precipitation may be concentrated near or ahead of the surface front.
    - This type of situation most likely occurs with cold fronts located in fairly close proximity to the jet stream and vigorous “advection lobe” shortwave troughs.

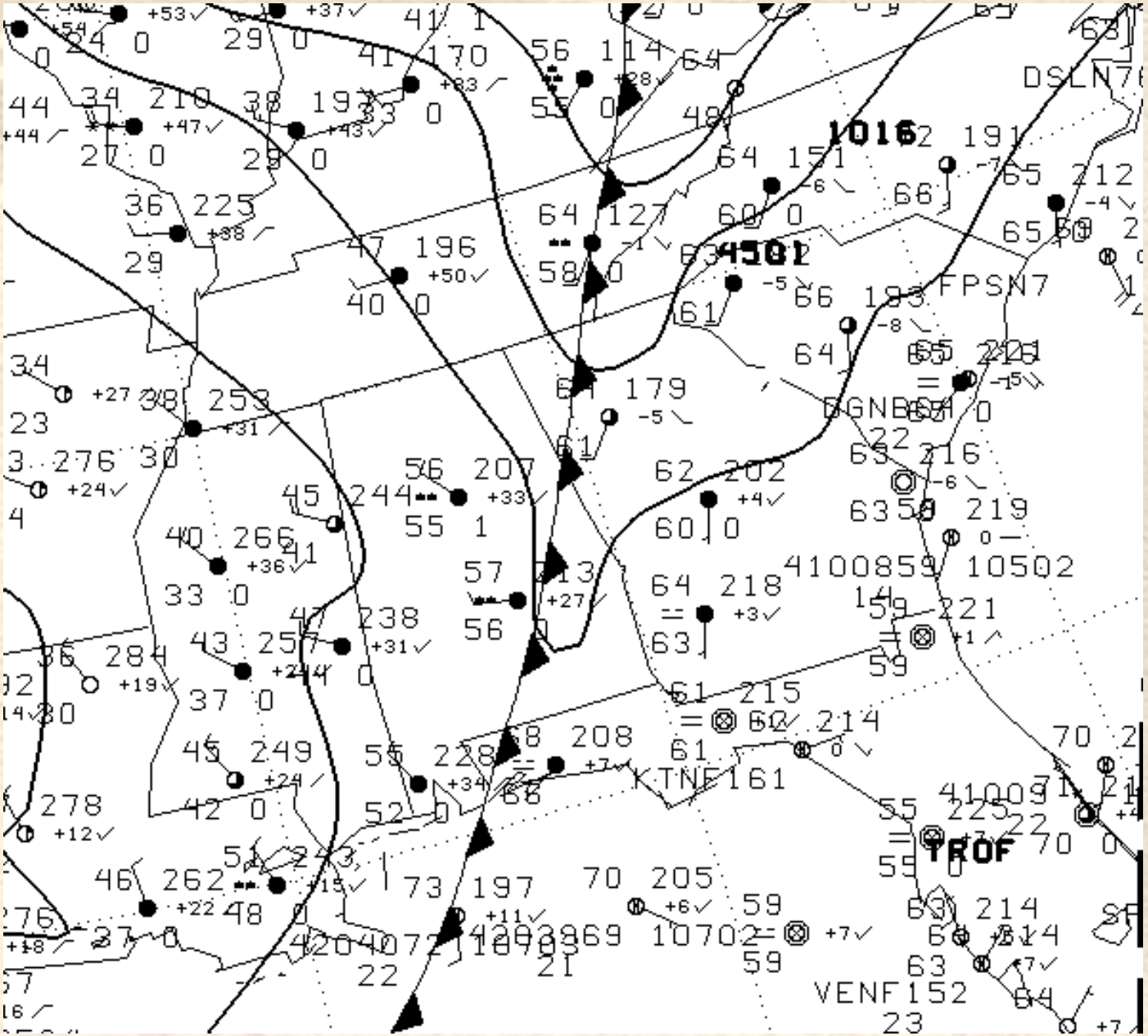
Frontal System Terminology

- In the presence of weak jet stream divergence, precipitation may be very spotty or totally absent near or ahead of the surface front.
  - This type of situation most likely occurs with cold fronts located in fairly close proximity to the jet stream, but in the absence of vigorous shortwave troughs, or in the presence of a trough dominated by shear vorticity (i.e., shear lobe)..

Types Of Fronts

Fronts are classified both by their physical structure and by their motion.

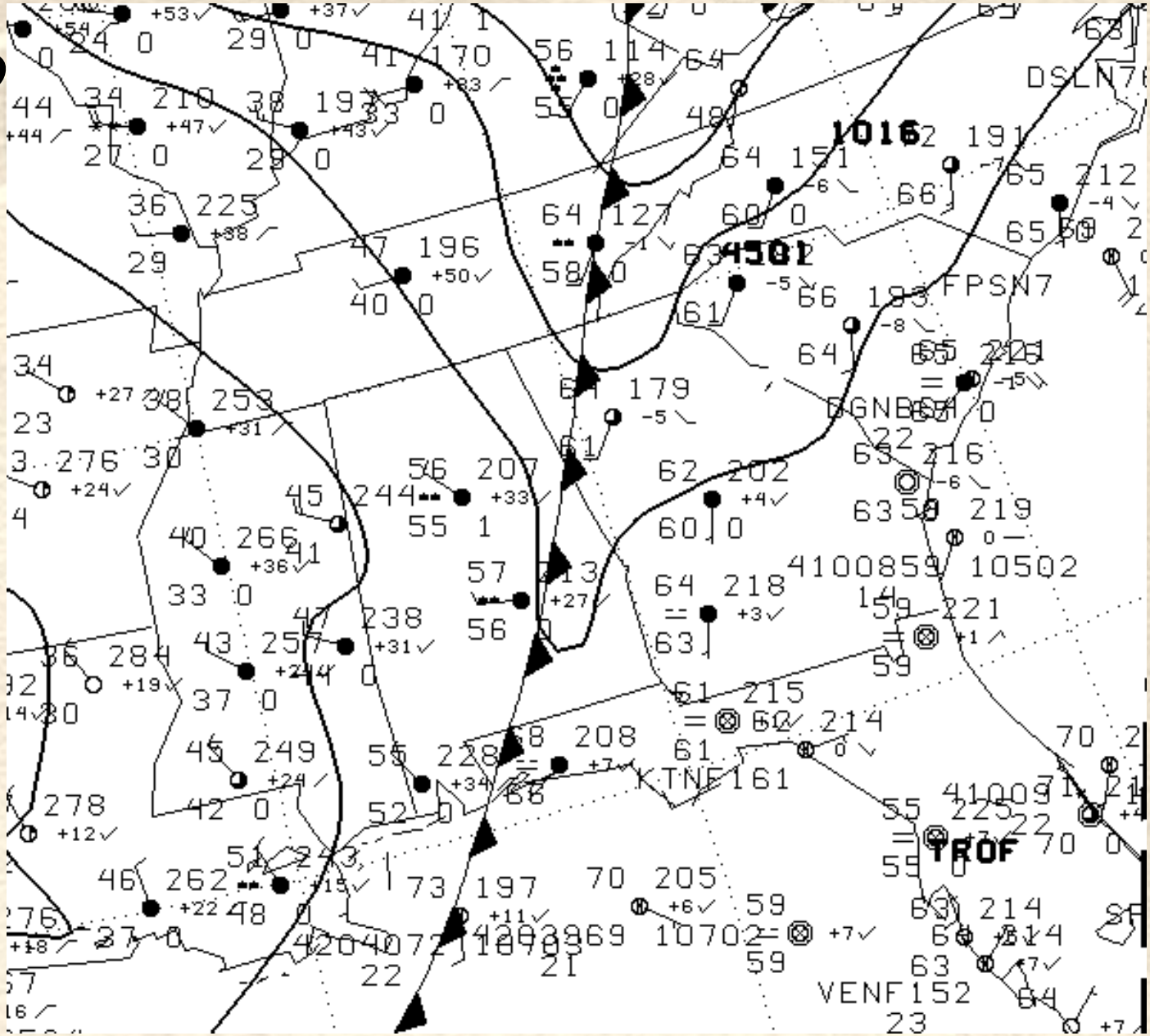
- Cold Front
  - Front in which colder air mass is advancing and displacing warmer air mass.

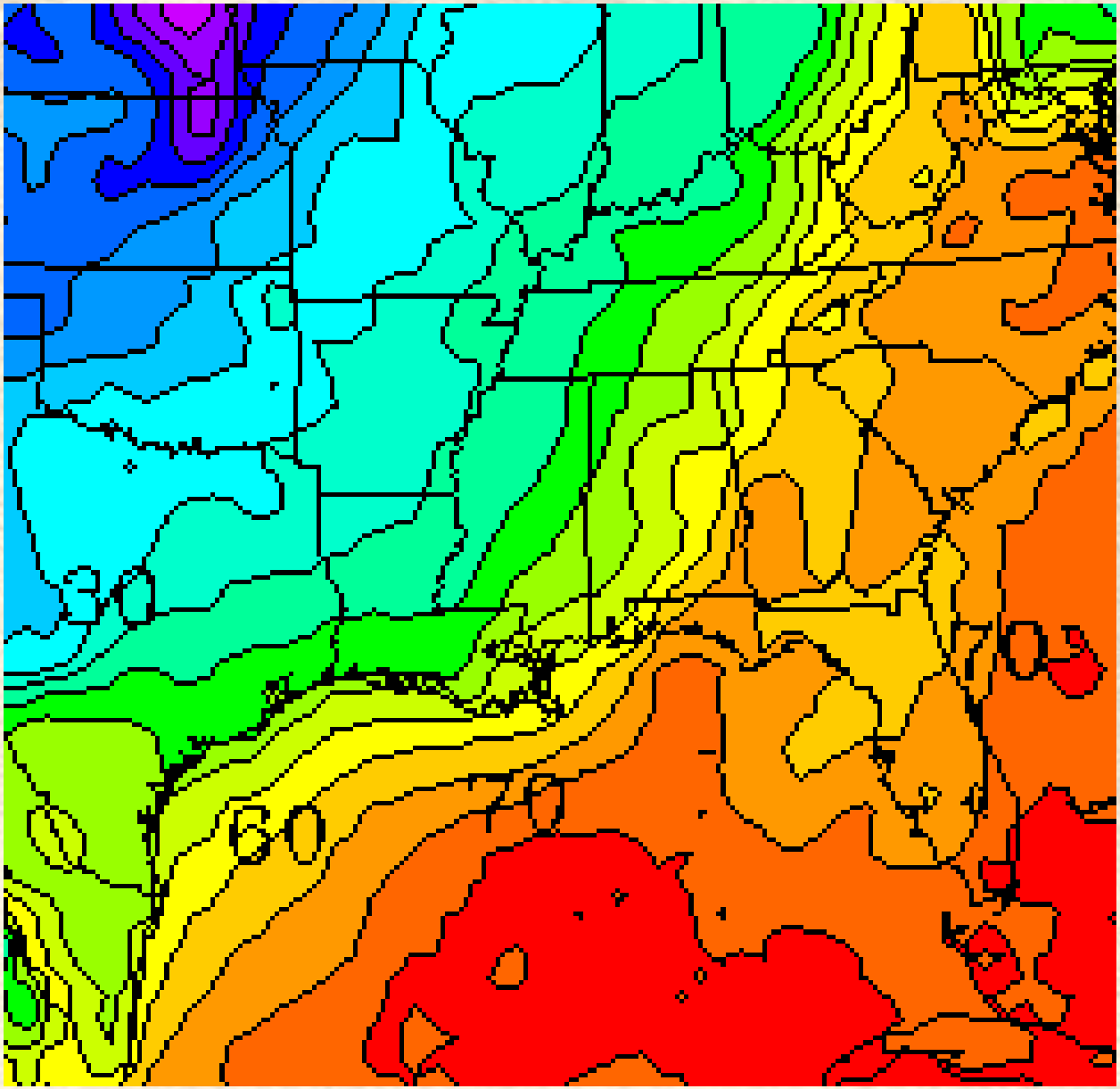

1016
4501
FPSN7
KTNF161
TROF
VENF152

Types Of Fronts

- Structure
  - Horizontal
    - Surface front is usually located in the pressure trough.
    - Winds turn cyclonically across frontal trough.
    - Temperature discontinuity exists across frontal surface;warmer air mass ahead of frontal surface, colder air mass behind it.

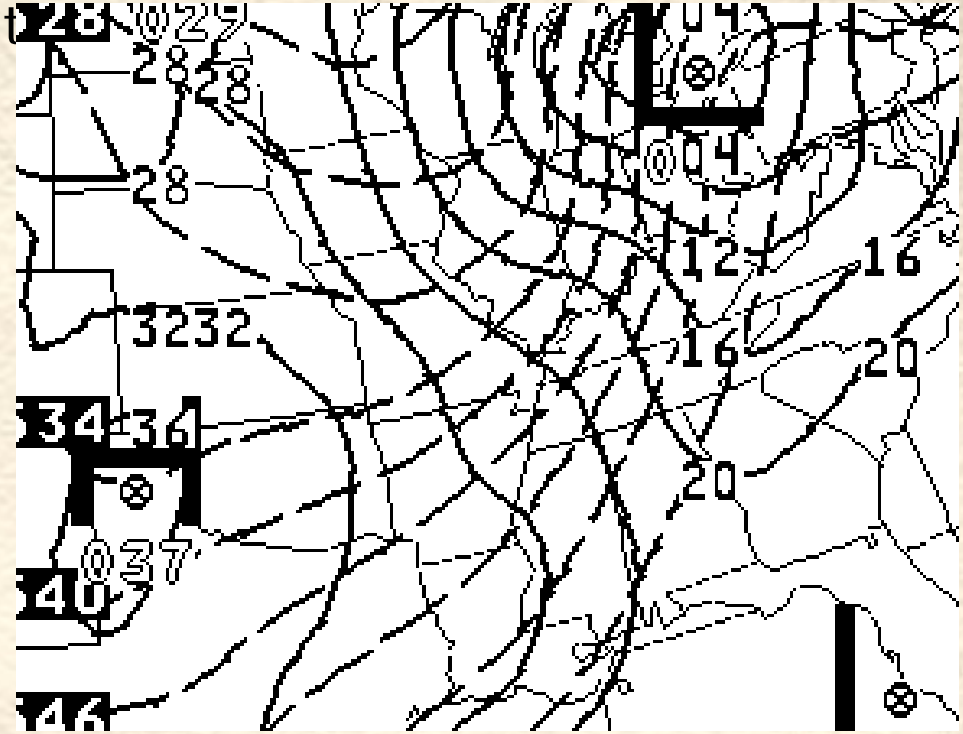
P


1016
4501
FPSN7
DSLN7
DGNB
4100859 10502
KTNE161
TROF
VENF152


60

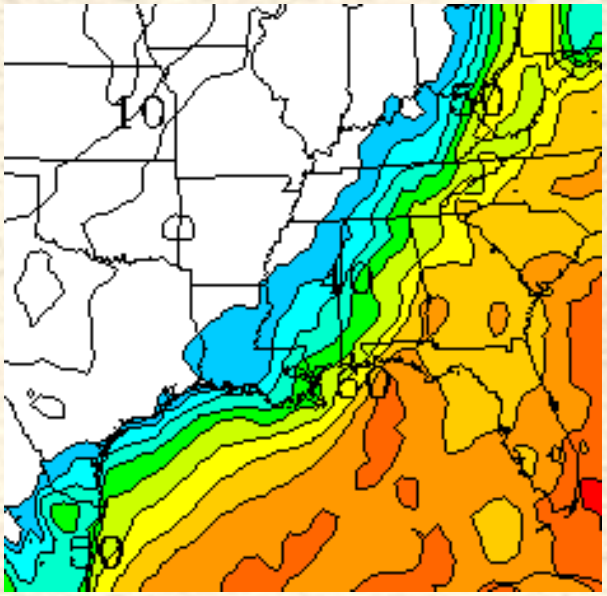
Types Of Fronts

- Surface front located on warm side of transition zone (i.e., on the warm edge of the



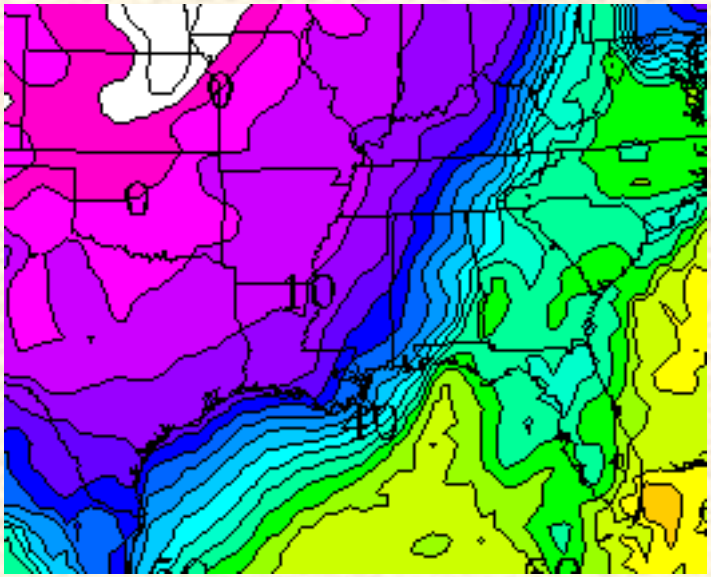
Types Of Fronts

- Moisture discontinuity exists across frontal surface.



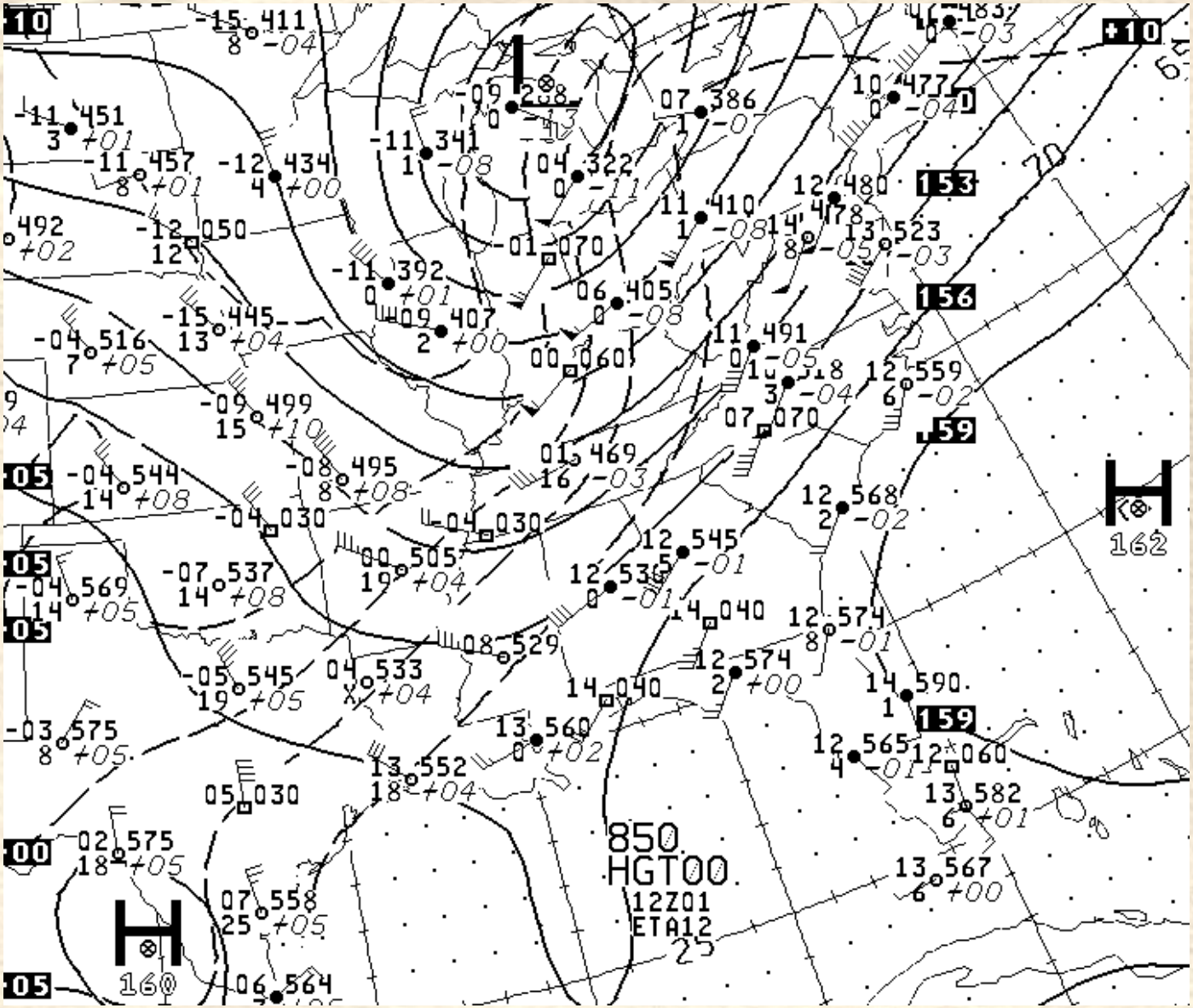
Types Of Fronts

- Equivalent Potential Temperature (i.e., Theta-e) discontinuity exists across frontal surface (i.e., combination of both temperature and moisture discontinuity).



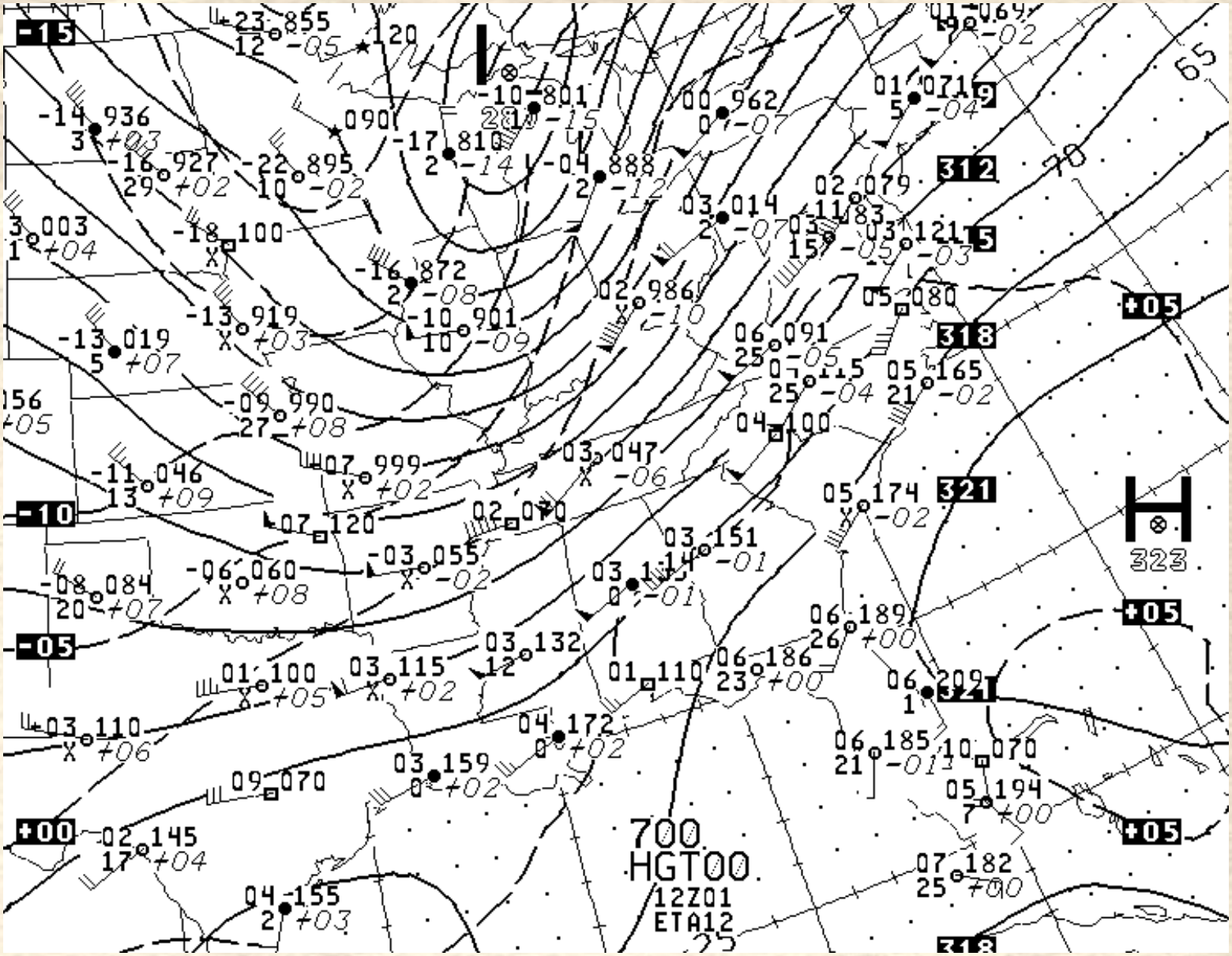
Types Of Fronts

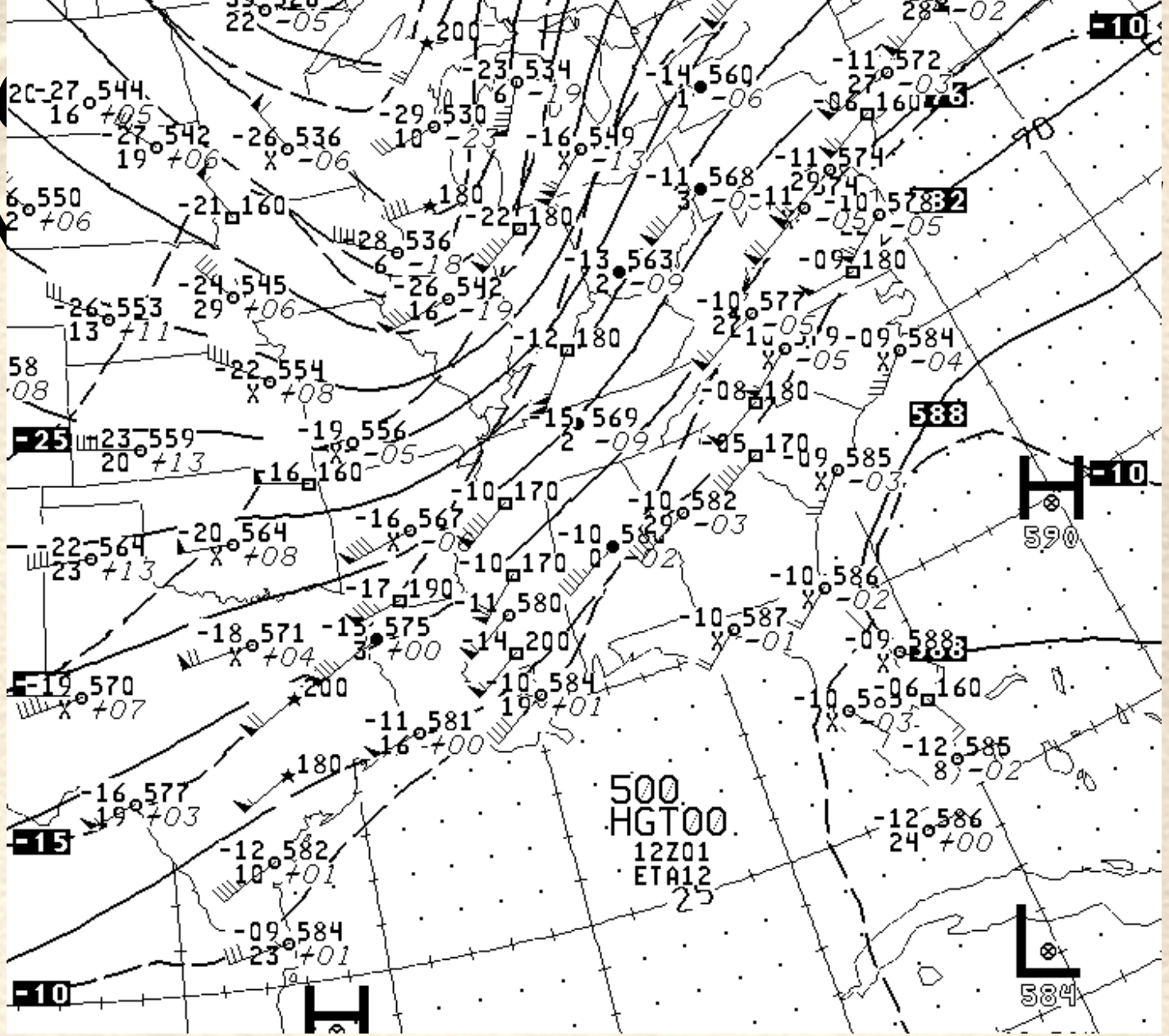
- Vertical
  - Frontal surface slopes over colder air mass.
  - Upper front usually found at 925 and 850 mb on cold side of surface front, but may be considerable distance from surface front, depending on the frontal slope.
  - Upper front on warm side of transition zone.

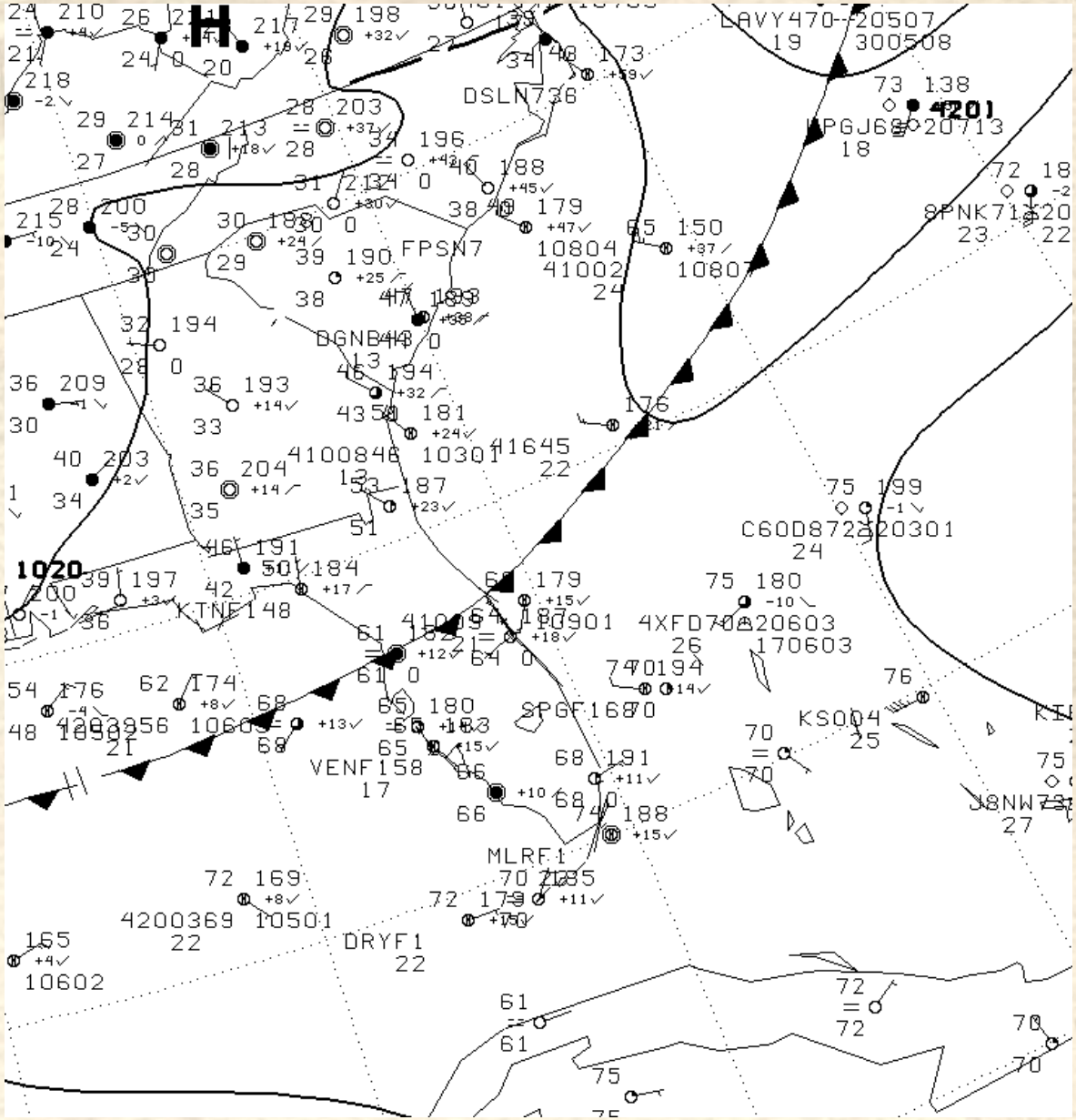

850
HGT00
12Z01
ETA12
25

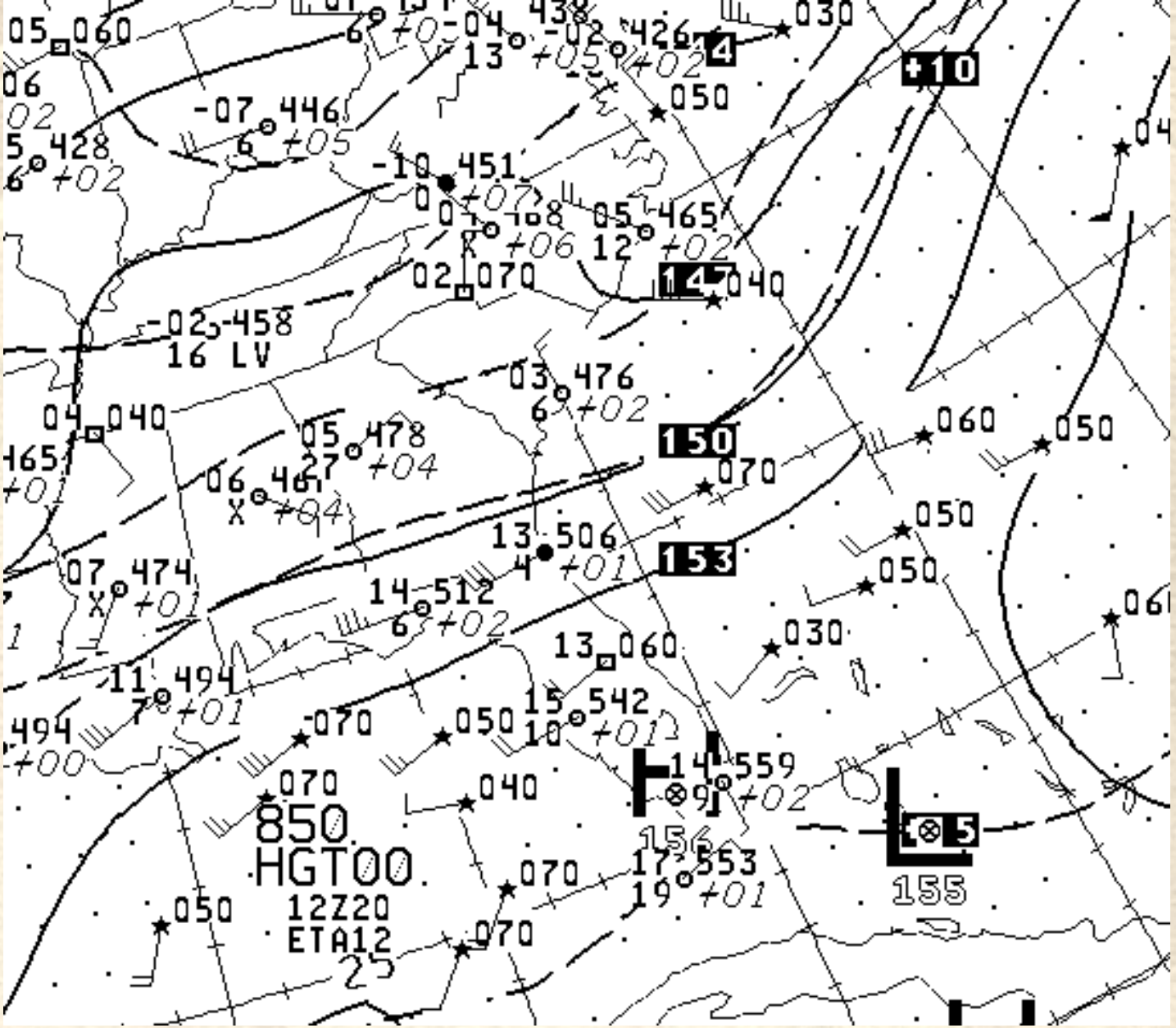
Types Of Fronts

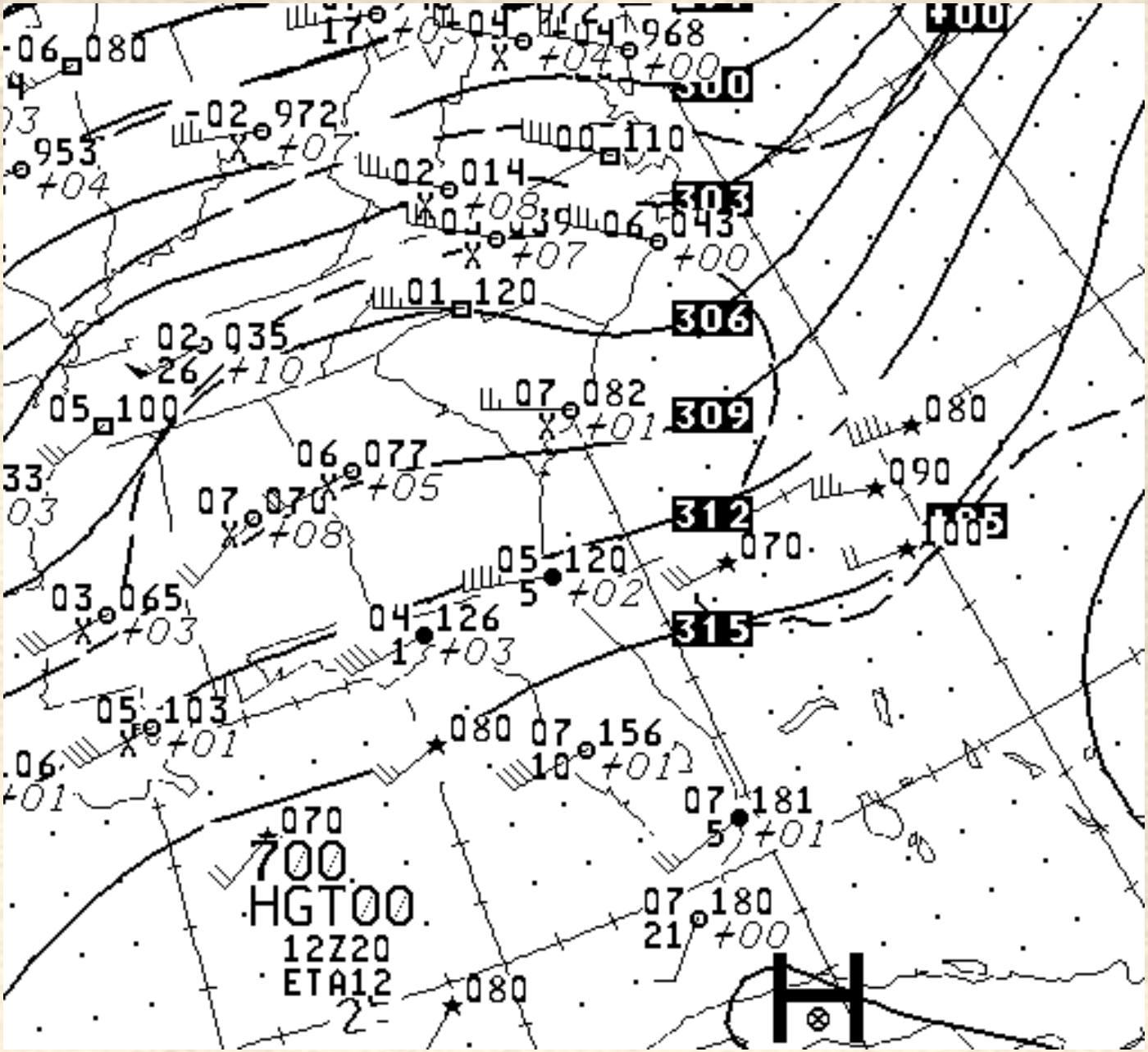
- Above 850 mb, frontal trough usually not found.
  - » Fronts with steep slopes generally visible up through 500
  - » Shallow fronts may only extend up to 850 mb, not above.
  - » Fronts aloft are often characterized on isobaric surfaces by an enhanced region of cyclonic wind shear.


700
HGT00
12Z01
ETA12


500
HGT00
12Z01
ETA12
25


1020
DSLN736
FPSN7
DGNB4
KTNE148
VENF158
SPGF1
MLRF1
DRYF1
KS004
LAVY470
4XFD70
C60D872
8PNK71
PGJ68
J8NW7


850
HGT00
12Z20
ETA12
25
155
156
150
153
16 LV


300
303
306
309
312
315
700
HGT00
12Z20
ETA12

Types Of Fronts

- RAOB sounding originating on cold side of surface front will exhibit backing winds in vertical within stable layer

Types of Fronts

- Active and Passive Cold Fronts

  The amount of cloudiness and precipitation associated with cold fronts is highly variable, and primarily depends on jet stream support, moisture availability, and stability of the atmosphere.

  - "Active" cold fronts.
    - Associated with extensive regions of cloudiness and precipitation

Types of Fronts

- Divergence in the jet stream produces extensive lifting of warmer air near the cold front.
  - » Generally located downstream of the upper trough axis, thereby residing within the divergent region of the wave pattern.

    This is a gradient wind lifting mechanism.
  - » Often associated with vigorous advection lobes of vorticity, signifying strong ageostrophic winds and divergence within a jet streak.

    This is a Q-G Omega Equation lifting mechanism.
  - » Warm advection patterns tend to be well developed in the warm air ahead and/or above the frontal surface.

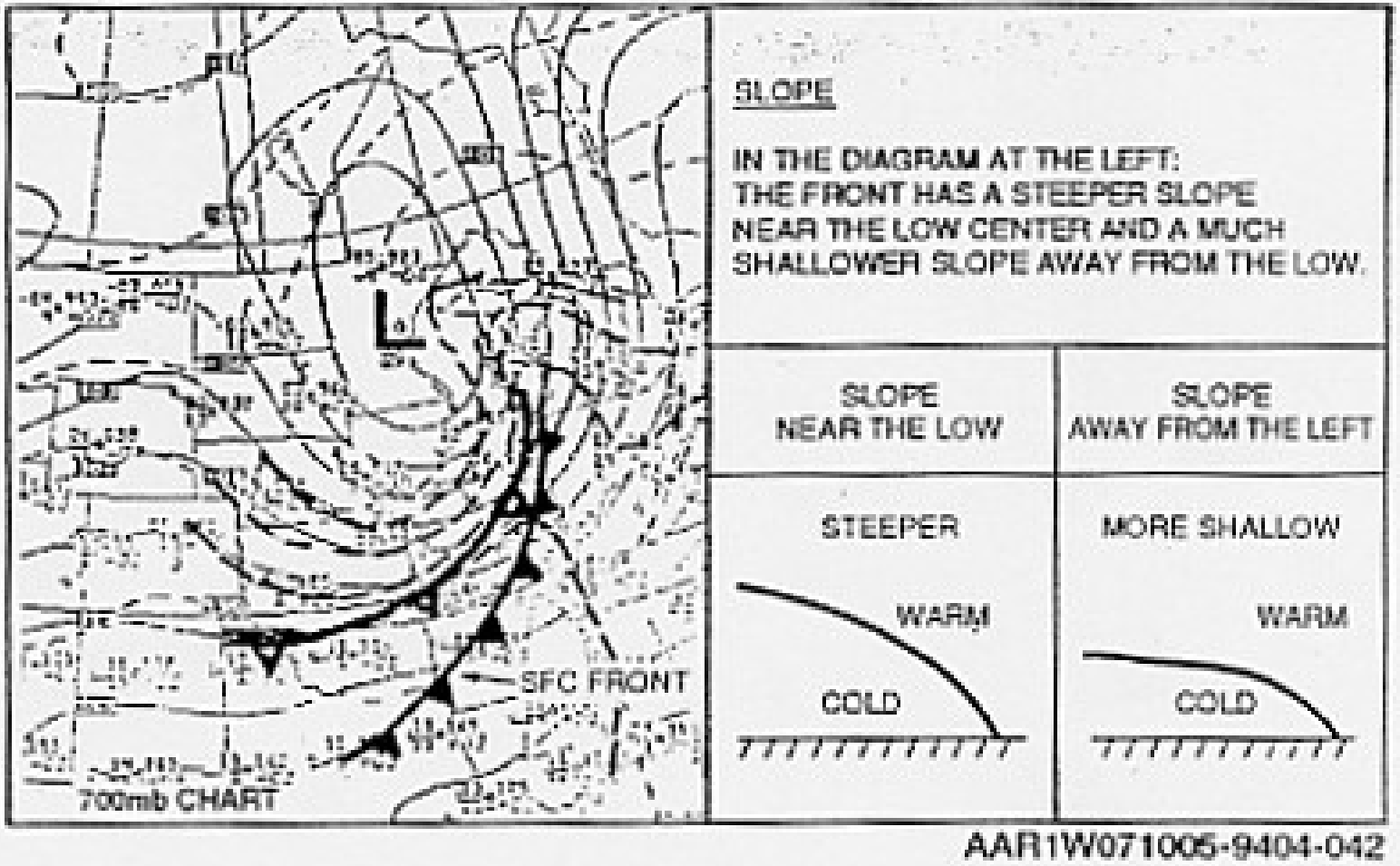
    This is a Q-G Omega Equation lifting mechanism.

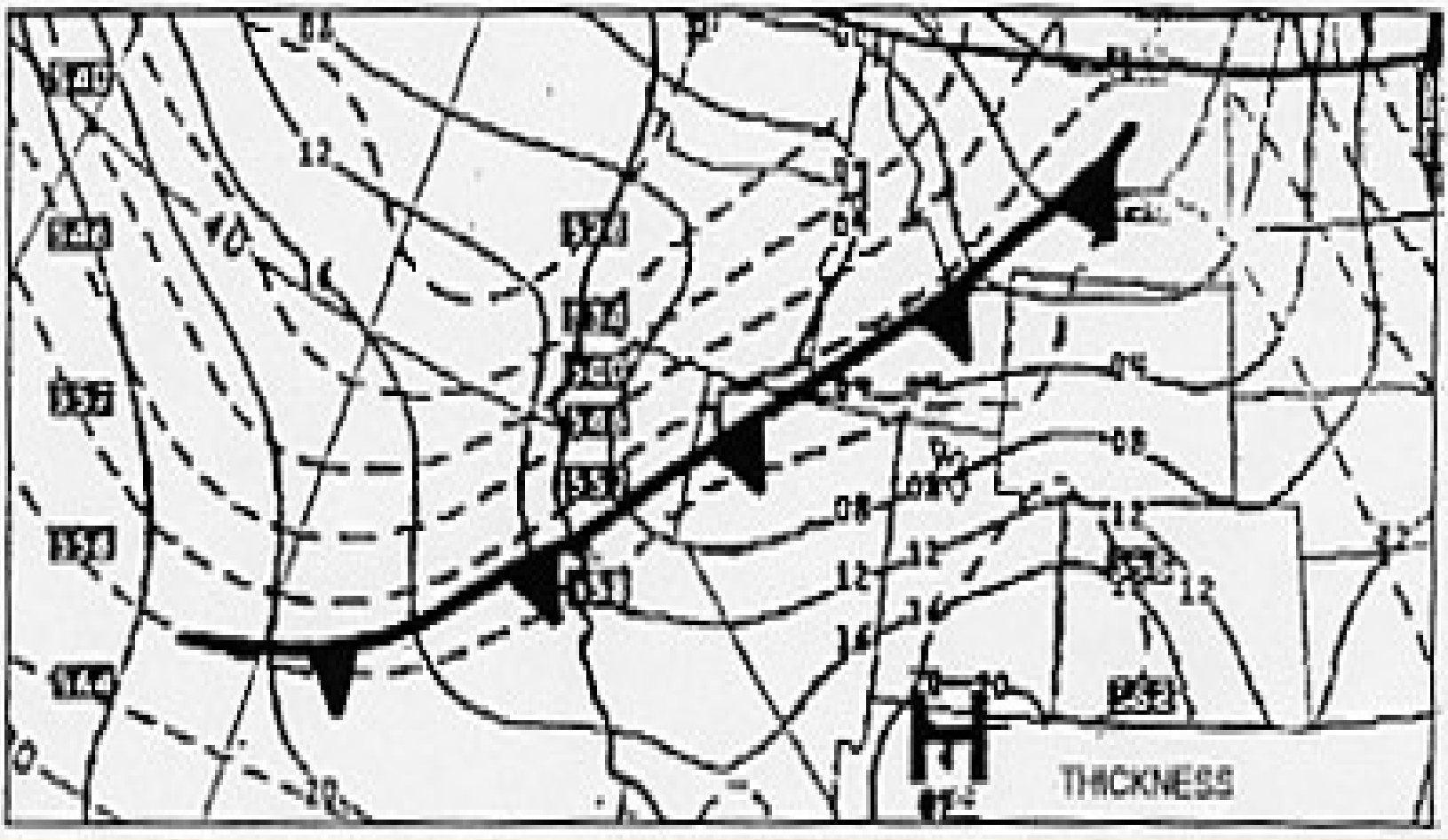
Types of Fronts

- Lifting of unstable atmosphere my produce numerous cumulonimbus showers and thunderstorms
- Lifting of stable air may produce extensive stratiform cloudiness and precipitation (i.e., nimbostratus).

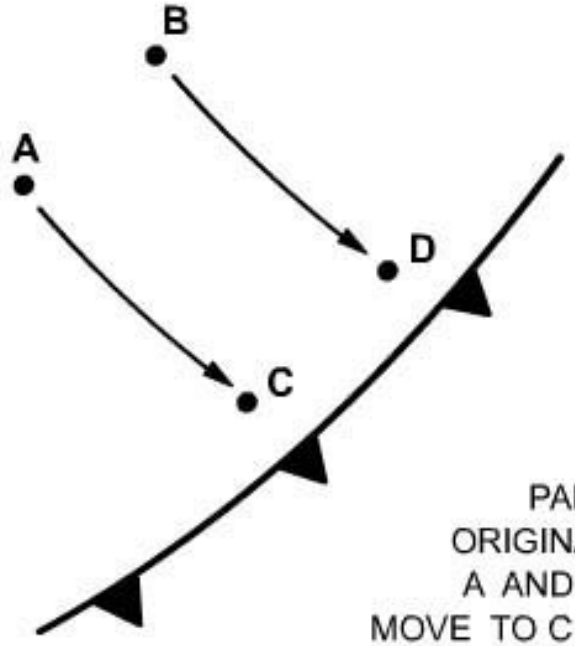
Types of Fronts

- Slow-moving active fronts are normally associated with a positively-tilted 500 mb trough. These fronts exhibit:
  - » Shallow slope with extensive warm advection “over-running” above the frontal inversion and extending well behind the surface front position.
  - » Thickness lines within transition zone are uniformly packed along length of front.
  - » Jet parallel to and above cold side of surface front with elongated jet streak and divergent jet entrance region downstream of the trough axis.
  - » Large area of precipitation and cloudiness behind surface front with cold air remaining humid behind front because of evaporation of precipitation falling through cold surface layer.

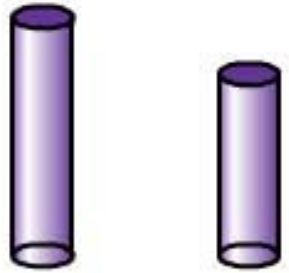

L
SFC FRONT
700mb CHART
SLOPE
IN THE DIAGRAM AT THE LEFT:
THE FRONT HAS A STEEPER SLOPE
NEAR THE LOW CENTER AND A MUCH
SHALLOWER SLOPE AWAY FROM THE LOW.
SLOPE
NEAR THE LOW
SLOPE
AWAY FROM THE LEFT
STEEPER
WARM
COLD
MORE SHALLOW
WARM
COLD
AAR1W071005-9404-042


THICKNESS

PPT - Cold Air Mass

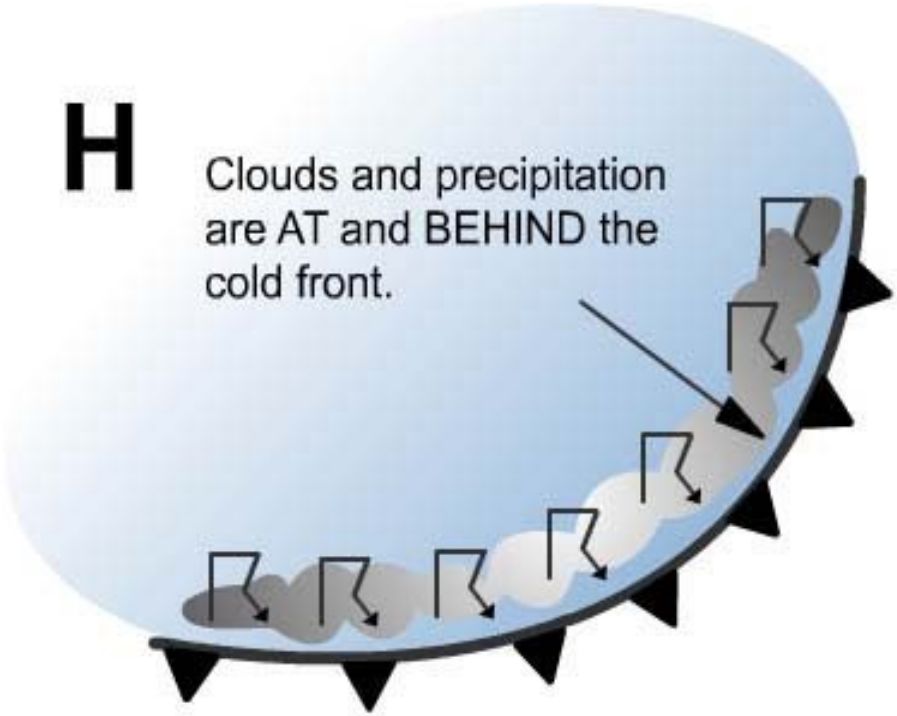


PARCELS ORIGINATE AT A AND B AND MOVE TO C AND D



DEPTHS OF COLUMN OF COLD AIR BENEATH FRONTAL SURFACE AT EACH POINT

WEATHER ASSOCIATED WITH ACTIVE COLD FRONT

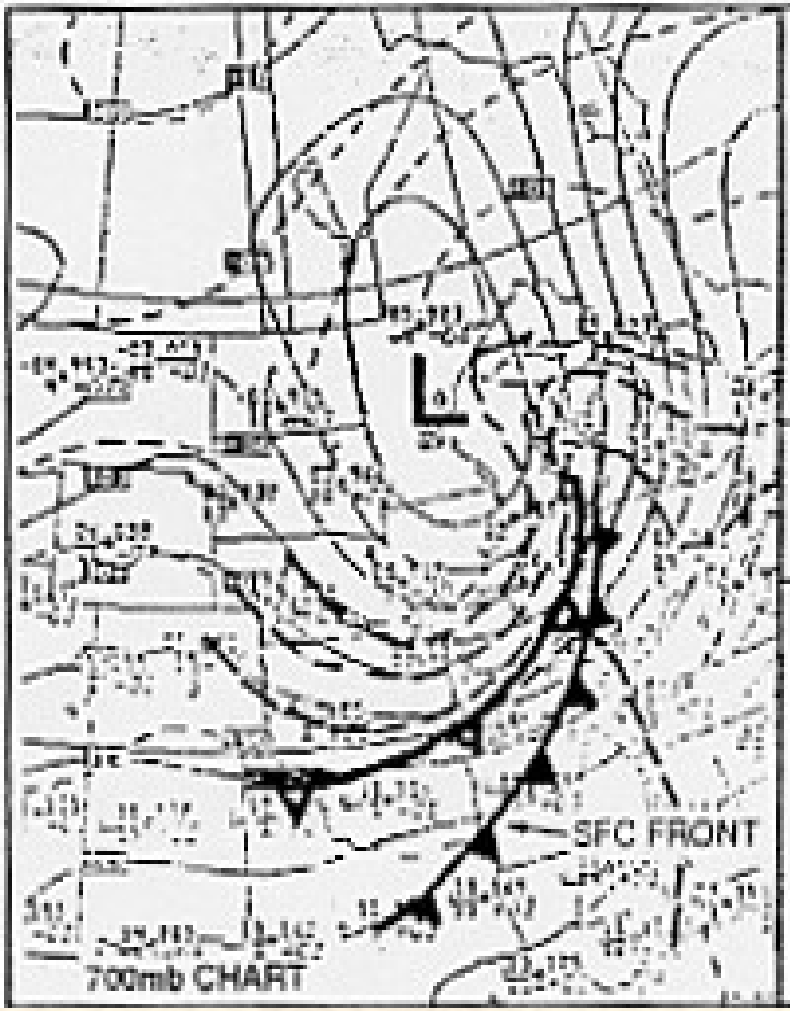


Types of Fronts

- Fast-moving active fronts are often associated with a neutrally or negatively-tilted 500 mb trough. These fronts exhibit:
  - » Steeper slope with only limited warm advection “over-running” above the frontal inversion, but often significant warm advection has already occurred ahead of the surface front position.
  - » Thickness lines within the transition zone are uniformly packed along the length of front close to the jet stream, but often spread apart equatorward of the jet stream (see passive front discussion below).

Types of Fronts

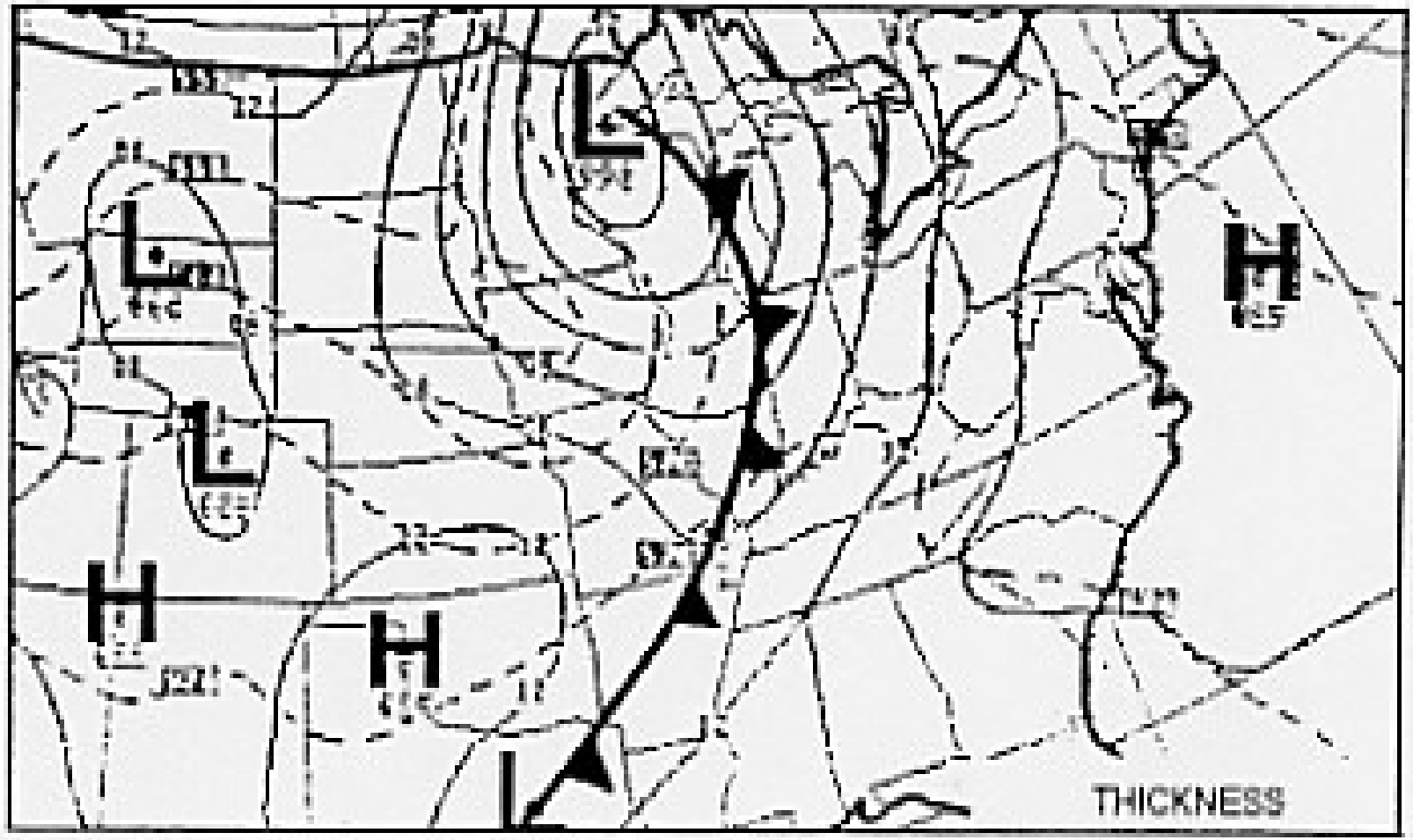
- Jet approaches and sometimes intersects the surface cold front position. Jet exit region is well developed with strong divergence downstream of the trough axis.
- Active precipitation and cloudiness along or ahead of surface front. Strong cold advection and subsidence produces rapid clearing and drying behind front.

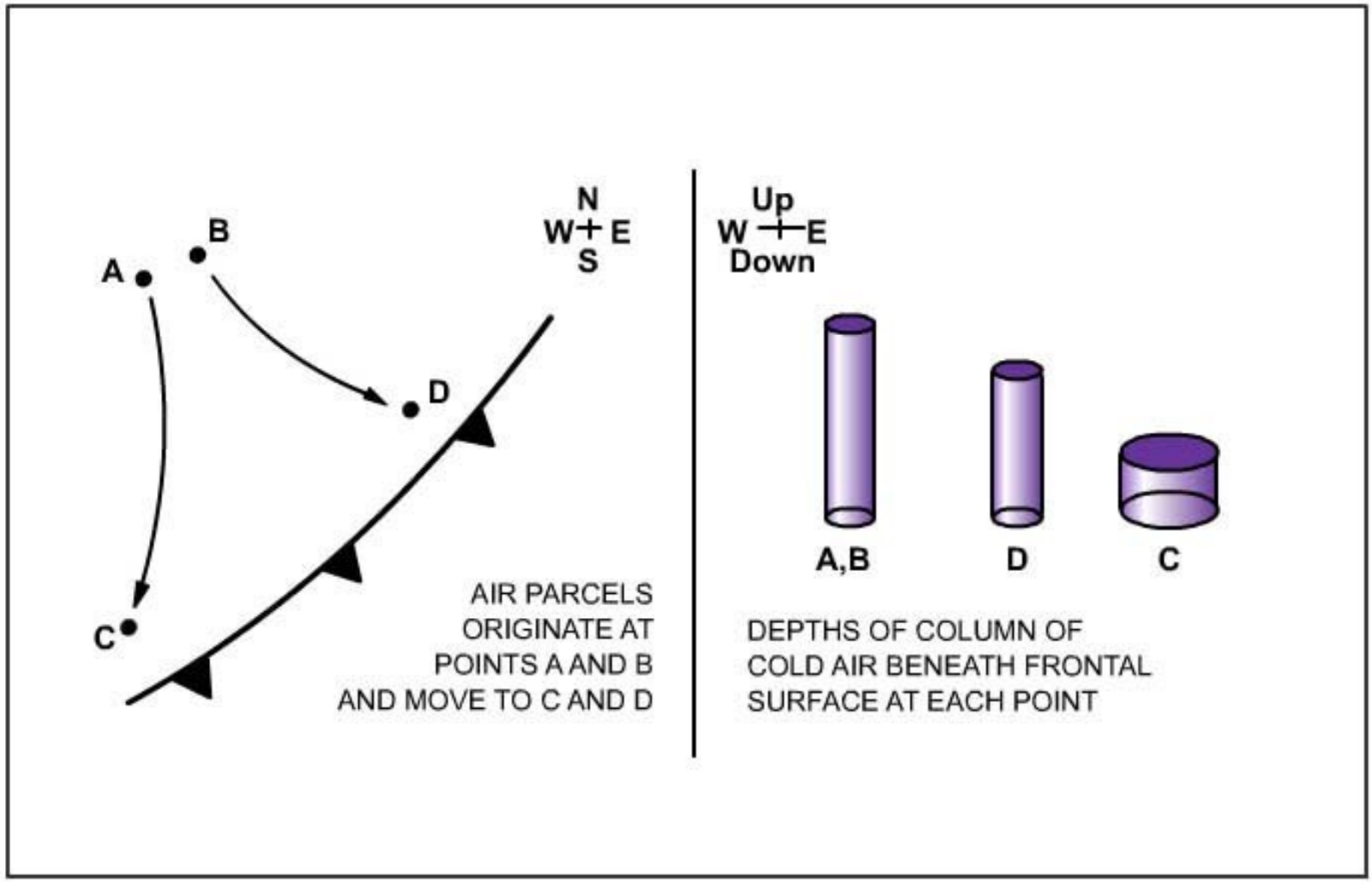


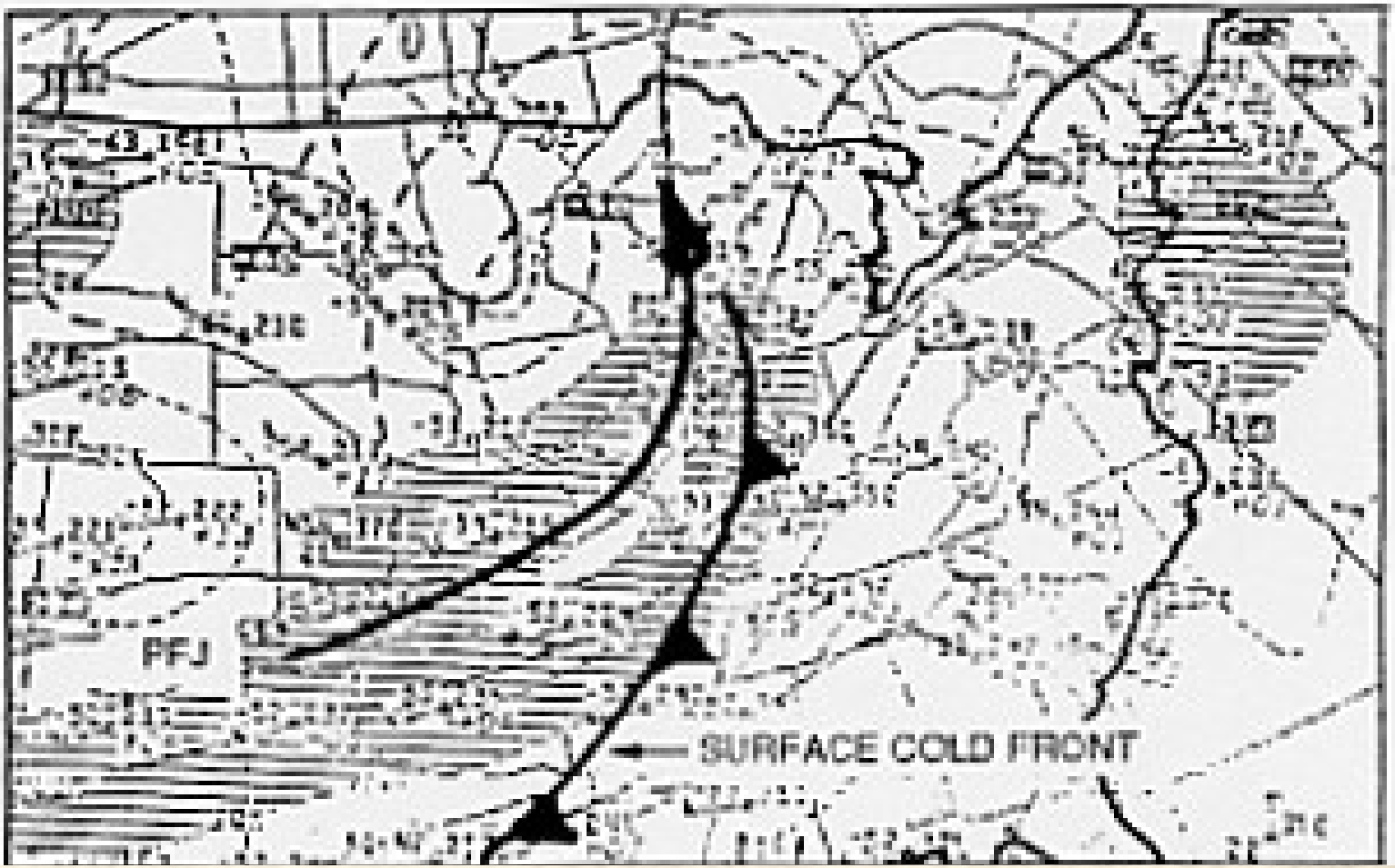
SLOPE

IN THE DIAGRAM AT THE LEFT:
THE FRONT HAS A STEEPER SLOPE
NEAR THE LOW CENTER AND A MUCH
SHALLOWER SLOPE AWAY FROM THE LOW.

SLOPE NEAR THE LOW	SLOPE AWAY FROM THE LEFT
STEEPER	MORE SHALLOW


THICKNESS


A
B
C
D
N
W
E
S
AIR PARCELS
ORIGINATE AT
POINTS A AND B
AND MOVE TO C AND D
Up
W
E
Down
A,B
D
C
DEPTHS OF COLUMN OF
COLD AIR BENEATH FRONTAL
SURFACE AT EACH POINT


PFJ
SURFACE COLD FRONT

Types of Fronts

- "Inactive" cold fronts.
  - Associated with very little cloudiness and precipitation
  - Lack of jet stream divergence results in absence of synoptic lifting of air mass. Here are some ways that fronts may become inactive:
    - » Front may be located upstream of the upper trough axis, thereby residing within the convergent region of the wave pattern.

    This is a gradient wind subsidence mechanism.
    - » Front may be associated with a shear lobe of vorticity, signifying a lack of divergence within a jet streak.

    Vorticity advection, an important vertical motion indicator in the Q-G Omega Equation, is absent.

Types of Fronts

» Environment immediately above or ahead of the front lacks a warm advection pattern.

Warm advection, an important lifting mechanism in the Q-G Omega Equation, is absent.

» Environment ahead of front is stable, thus preventing sufficient lifting for cloud and precipitation formation.

» Environment ahead of front is dry, thus inhibiting cloud and precipitation formation.

Types of Fronts

- Example of an inactive cold front: The Passive Front.

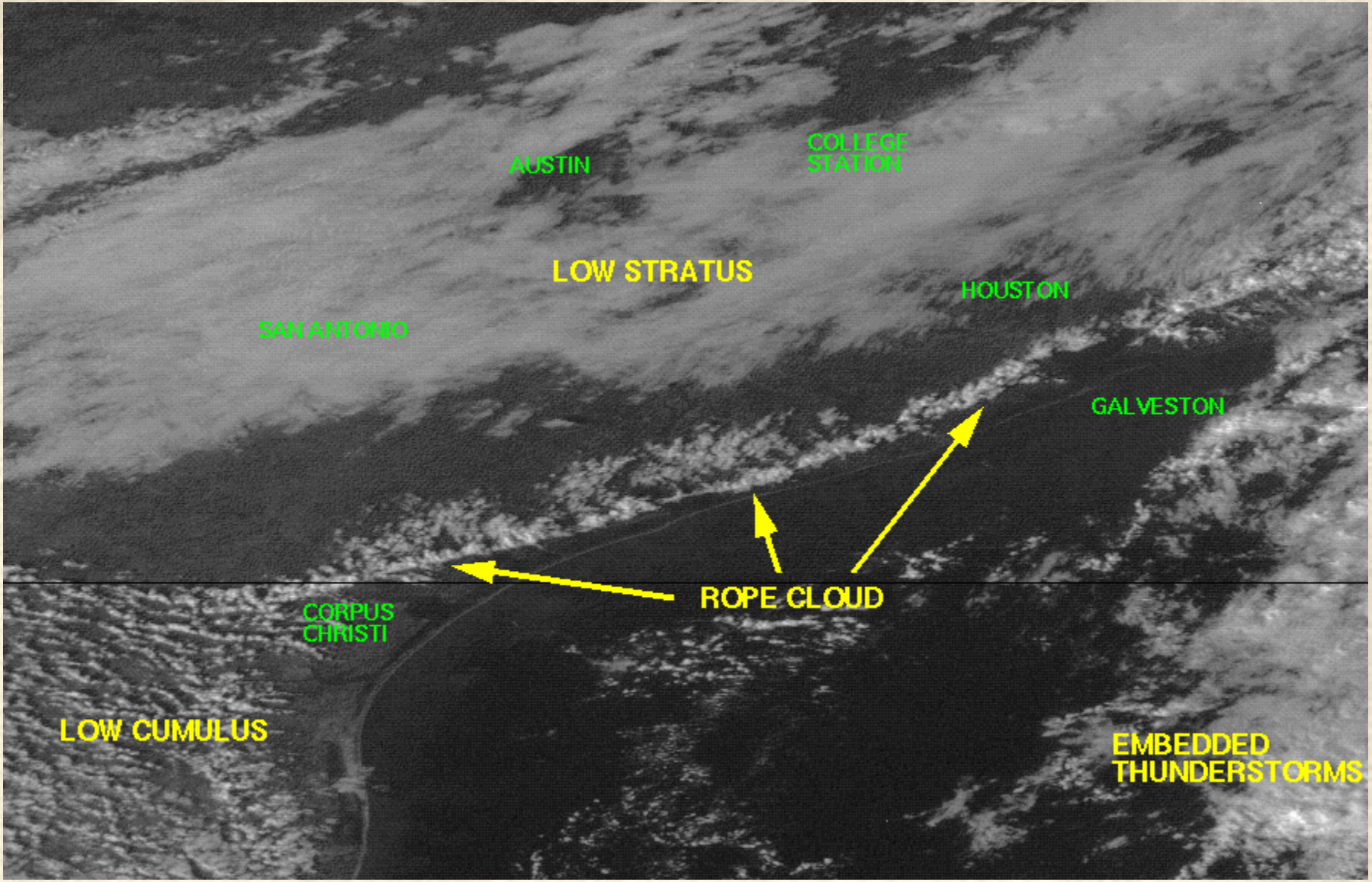
  Passive fronts can be fast or slow moving, but they almost always are “inactive” (i.e., void of significant clouds and precipitation). These fronts exhibit:

  » A blunt steeply sloped front in the boundary layer, but a very shallow slope above 900 mb. Insignificant warm advection “over-running” occurs above the frontal inversion.

  » Thickness lines become widely spaced the farther equatorward along the front, indicative of the shallow nature of the cold air mass.

Types of Fronts

- Passive fronts are far removed from their parent upper-level trough and are well equatorward of the jet stream with an absence of jet-induced divergence and lifting.
- Passive fronts generally extend westward of the longitude of the upper-level trough, thereby residing on the upper-tropospheric convergence and subsidence side of the wave pattern.
- Passive fronts are generally void of cloudiness and precipitation. Not only is there an absence of jet-supported divergence and lifting, but in general, the atmosphere on the warm side of the front is stable.

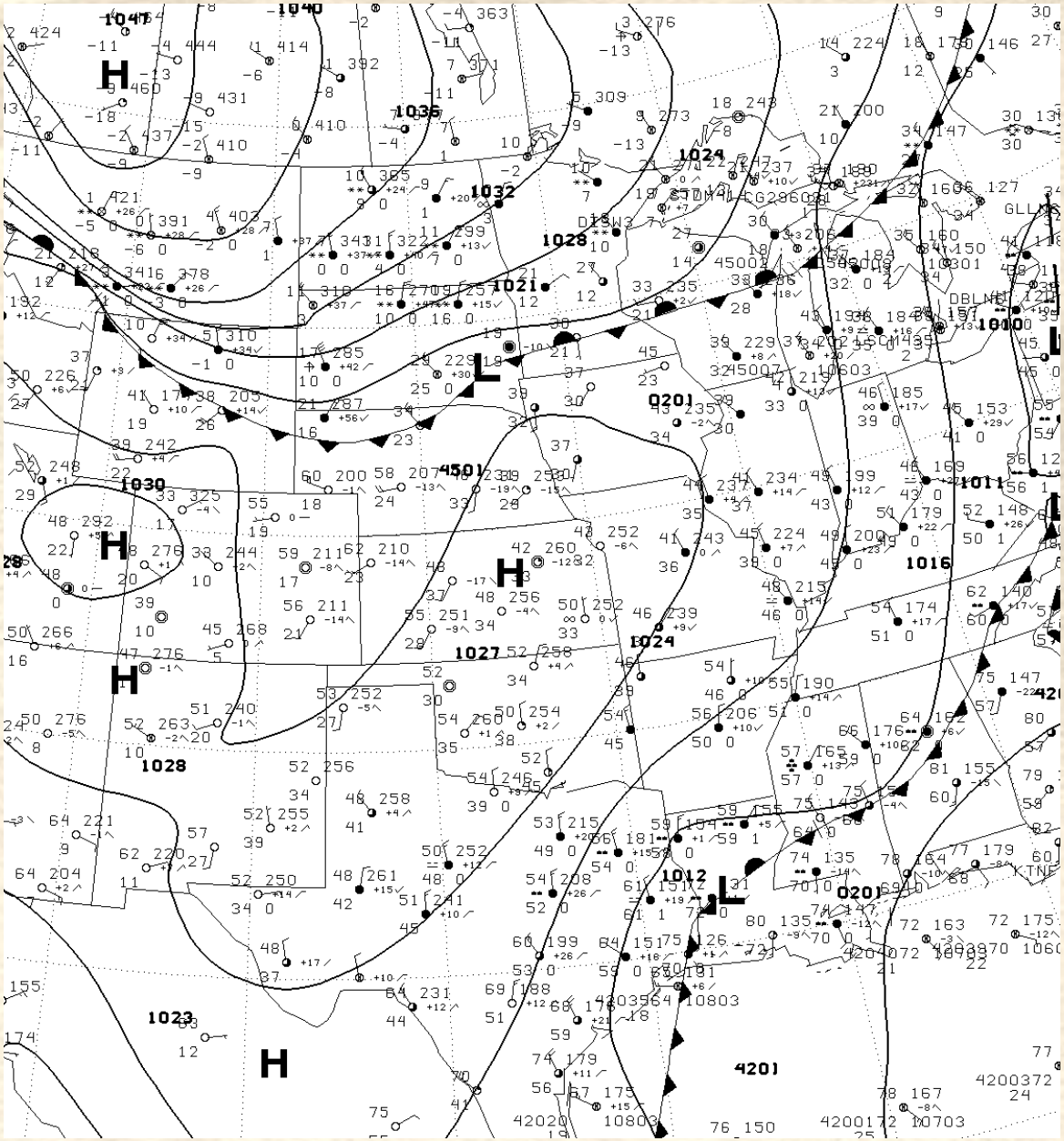

AUSTIN
COLLEGE STATION
LOW STRATUS
HOUSTON
SAN ANTONIO
GALVESTON
ROPE CLOUD
CORPUS CHRISTI
LOW CUMULUS
EMBEDDED THUNDERSTORMS

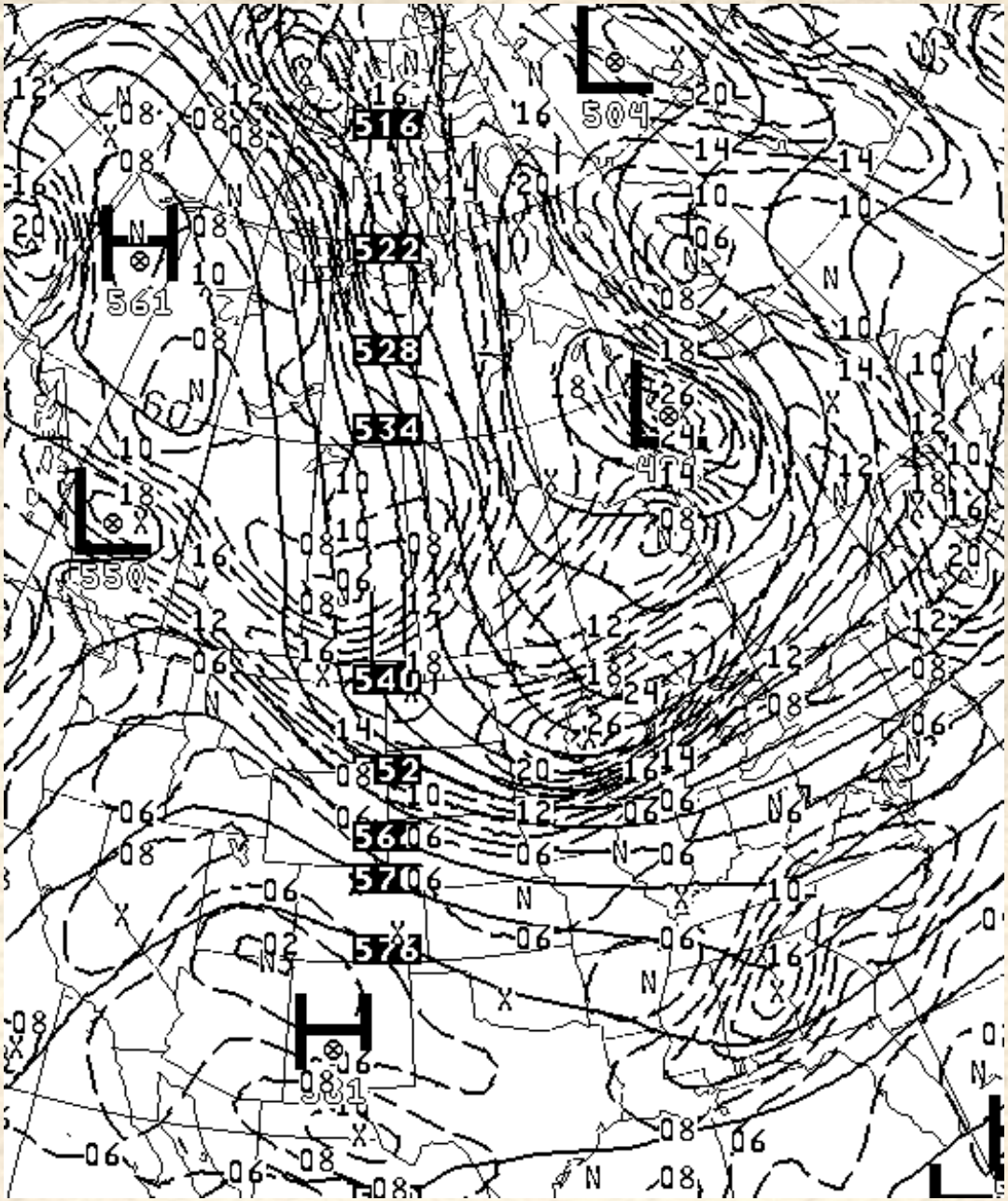
Types of Fronts

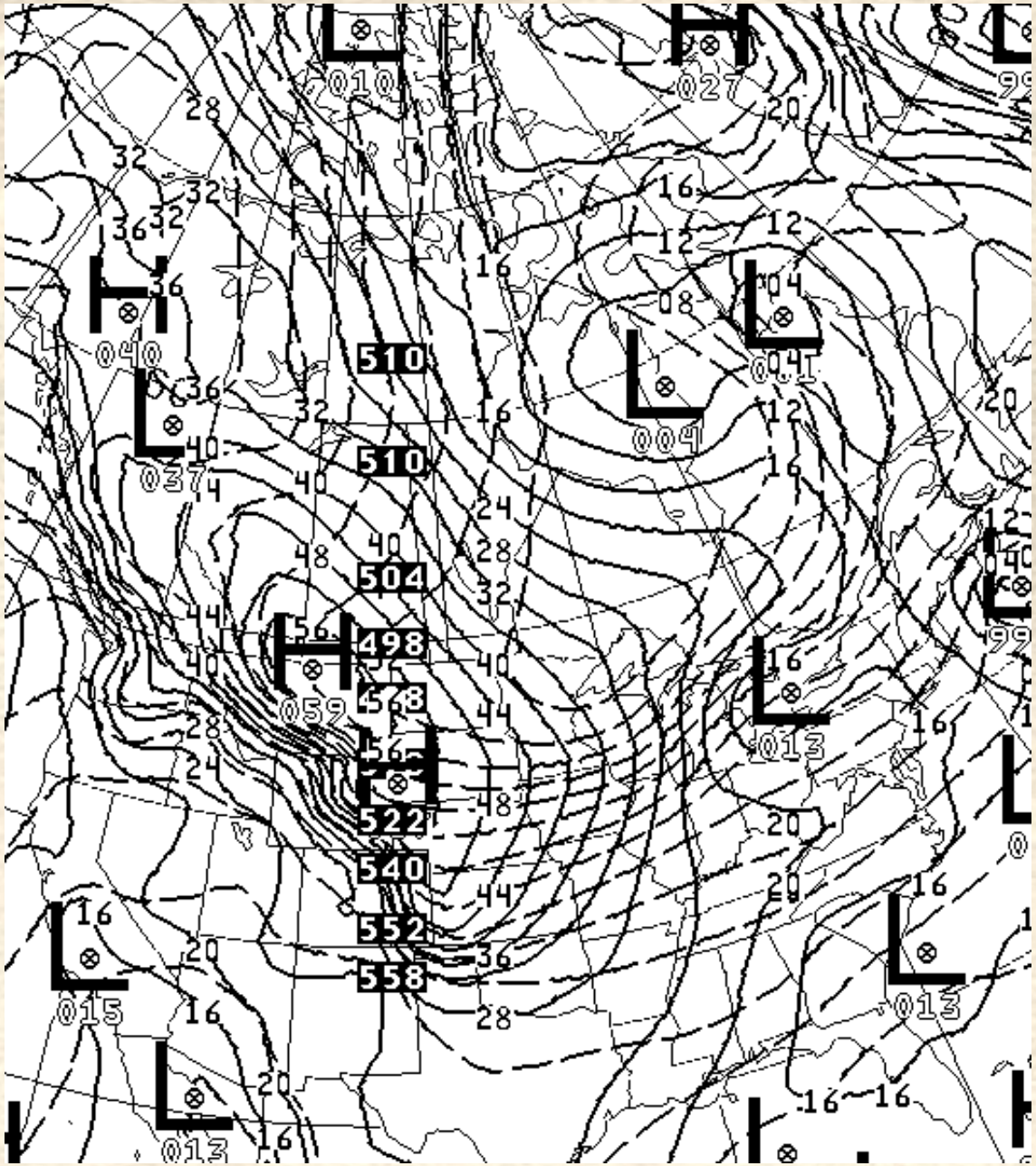
- Passive fronts are most commonly located within the most equatorward extensions of the polar front. Some of the characteristics of cold fronts as they move equatorward include:
  - » A decrease in thickness packing.
  - » An increase in the distance between surface front and tightest thickness packing.
  - » A decrease in thermal contrast across the front as cold air mass moves over increasingly warmer surface..

Types of Fronts

- Arctic cold fronts
  - The arctic cold front is a special case of cold front. Many times it represents a reinforcement of extremely cold cA air, often following an earlier invasion of cP air.
  - The arctic front may have either a shallow or steep slope at high latitudes, but nearly always has a very shallow slope at lower latitudes.
  - Steeper arctic fronts normally are associated with a significant short wave trough and attendant jet streak.

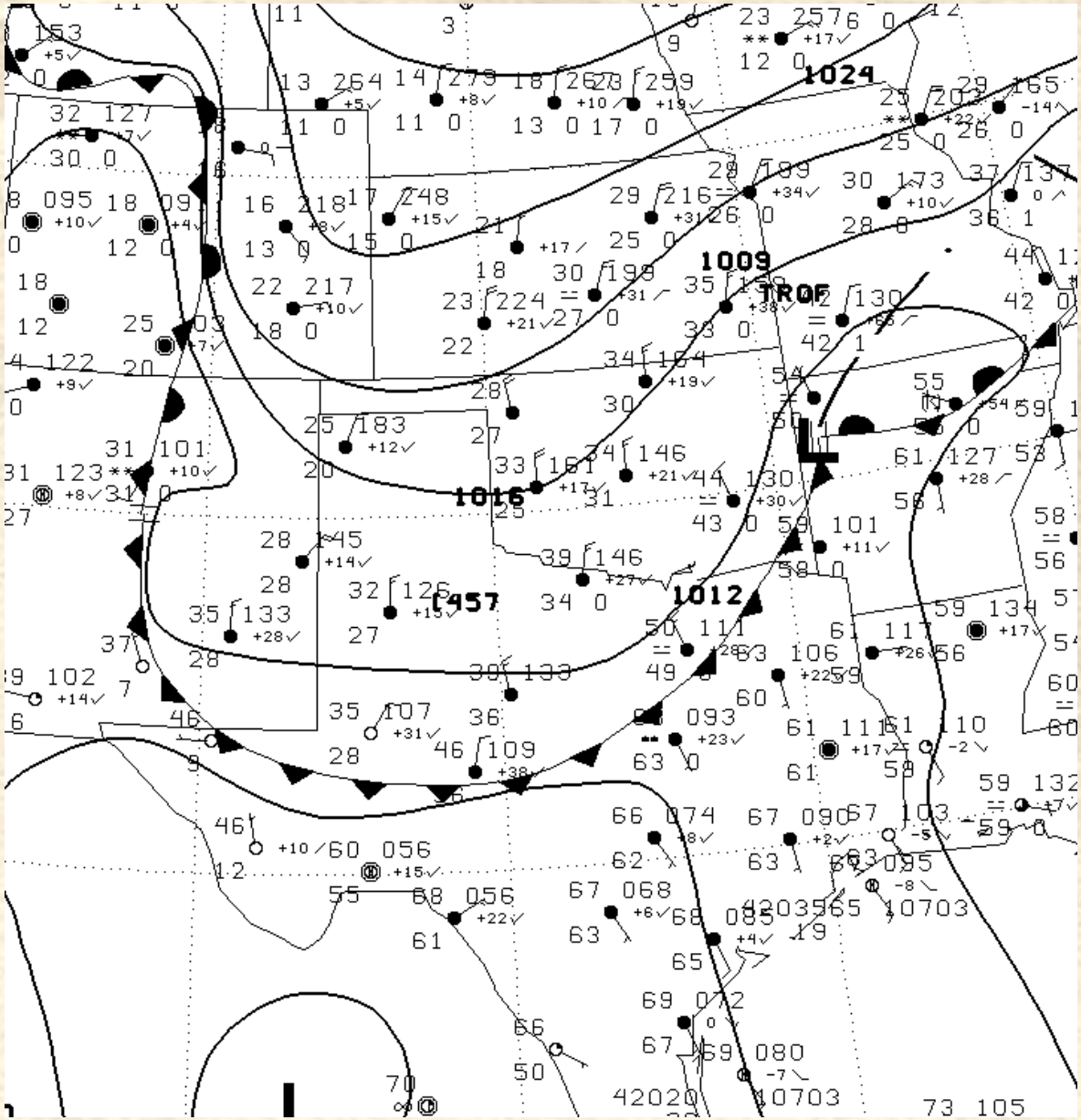

H
L
1036
1032
1028
1024
1021
1030
1027
1023
1012
1000
1011
1016
4201


516
522
528
534
540
546
552
558
564
570
576
561
550
504
414
561


510
510
504
498
522
540
552
558

Types of Fronts

- Arctic air sometimes “flows” as a density current in directions dictated more by terrain than by jet stream forcing.
  - » Shallow arctic air frequently dams up against mountains, as shown by the tight isobar and thickness packing along the east side of the Rockies in Montana, Wyoming, and Colorado in the figure above.
  - » Arctic air frequently spreads very far south through the Plains and Mississippi River Basin, almost like it were “flowing like water” over rather flat gently sloping terrain toward the Gulf of Mexico.

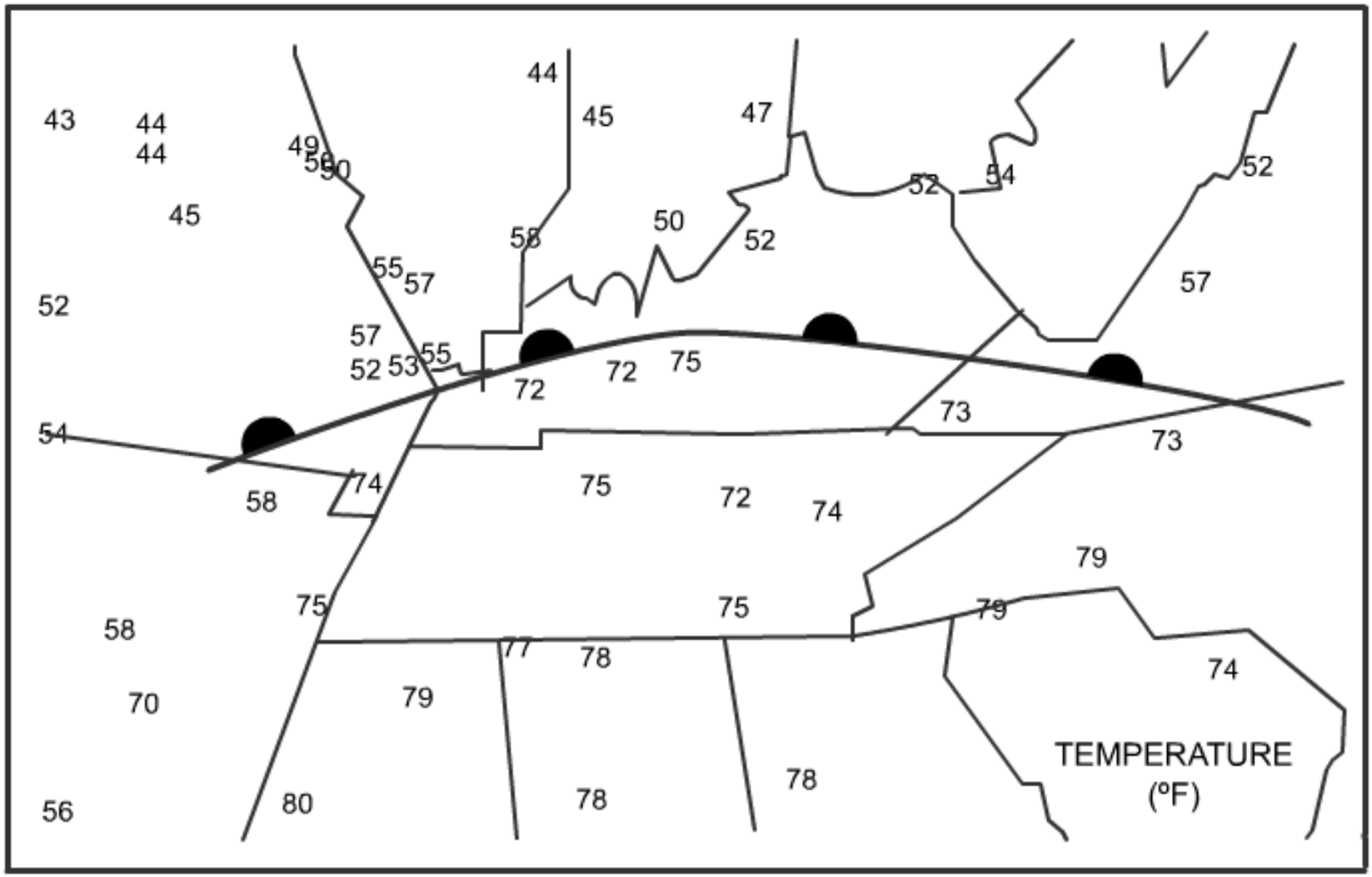

1024
1009
TROF
1016
1012
1457

Types of Fronts

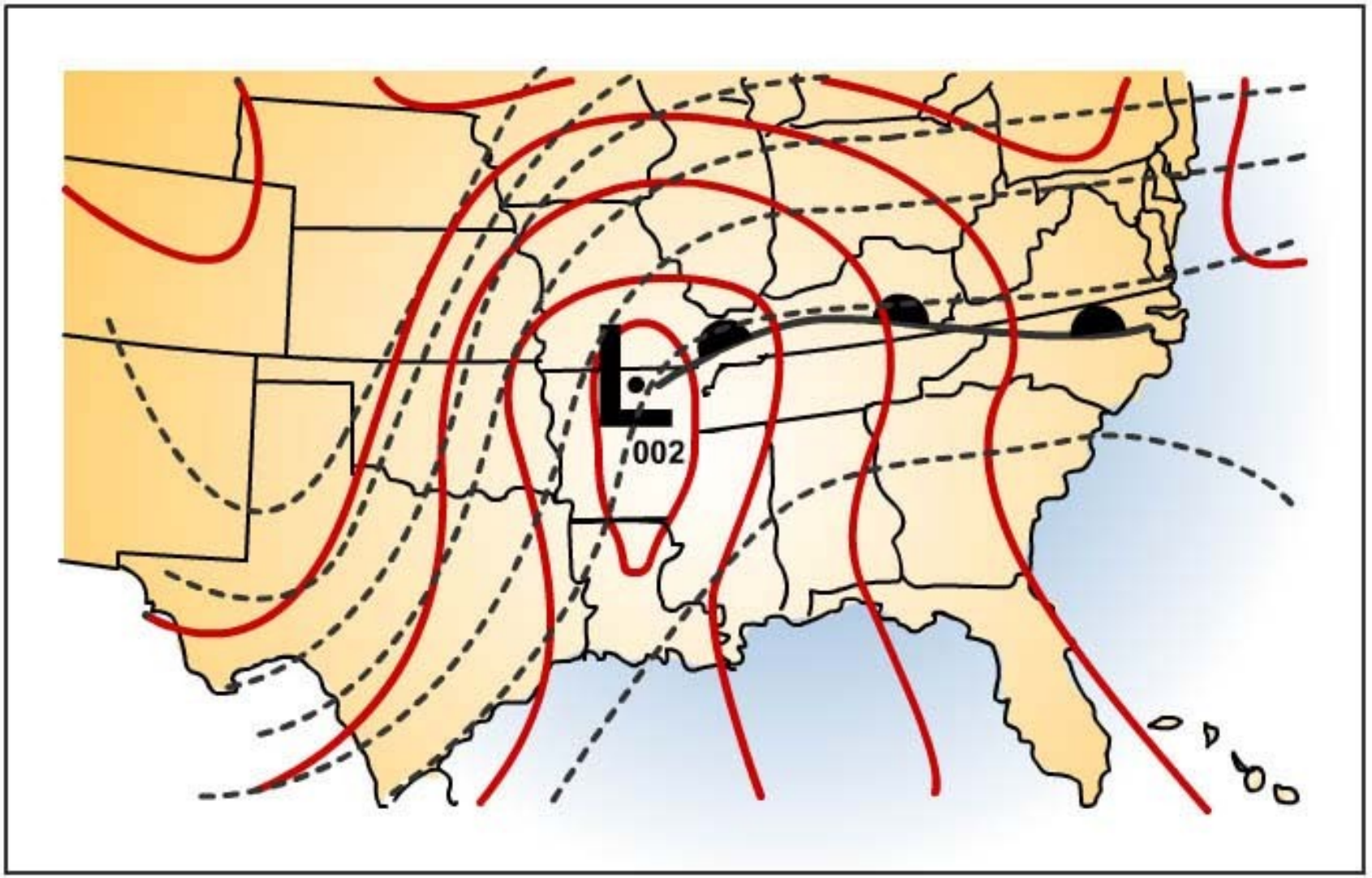
- Cold front passage (FROPA), in the “classic text book sense”, is marked by the following indications (eastern U. S. example):
  - Wind shifting from a southerly to northerly direction.
  - Sudden or sustained drop in temperature and dew point.
  - Falling pressure ahead of the front, followed by abrupt and sustained rise during and after FROPA.
  - Cloudiness and precipitation is highly variable, but if precipitation occurs, it is more likely to be convective than stratiform.

Types of Fronts

- Warm Front
  - Warmer air mass is advancing and replacing retreating colder air mass.
  - Structure
    - Horizontal
      - Temperature discontinuity across frontal surface.
      - Surface front and upper front*:*
        - » Located on warm side of transition zone.
        - » Generally located in pressure/contour trough.


43
44
44
45
49
50
44
45
47
52
54
52
50
52
55
57
57
52
57
52
53
55
72
72
75
73
73
54
74
58
75
72
74
79
75
75
79
58
77
78
74
70
79
TEMPERATURE
(ºF)
78
56
80
78

PPT: Warm Frontal



Types of Fronts

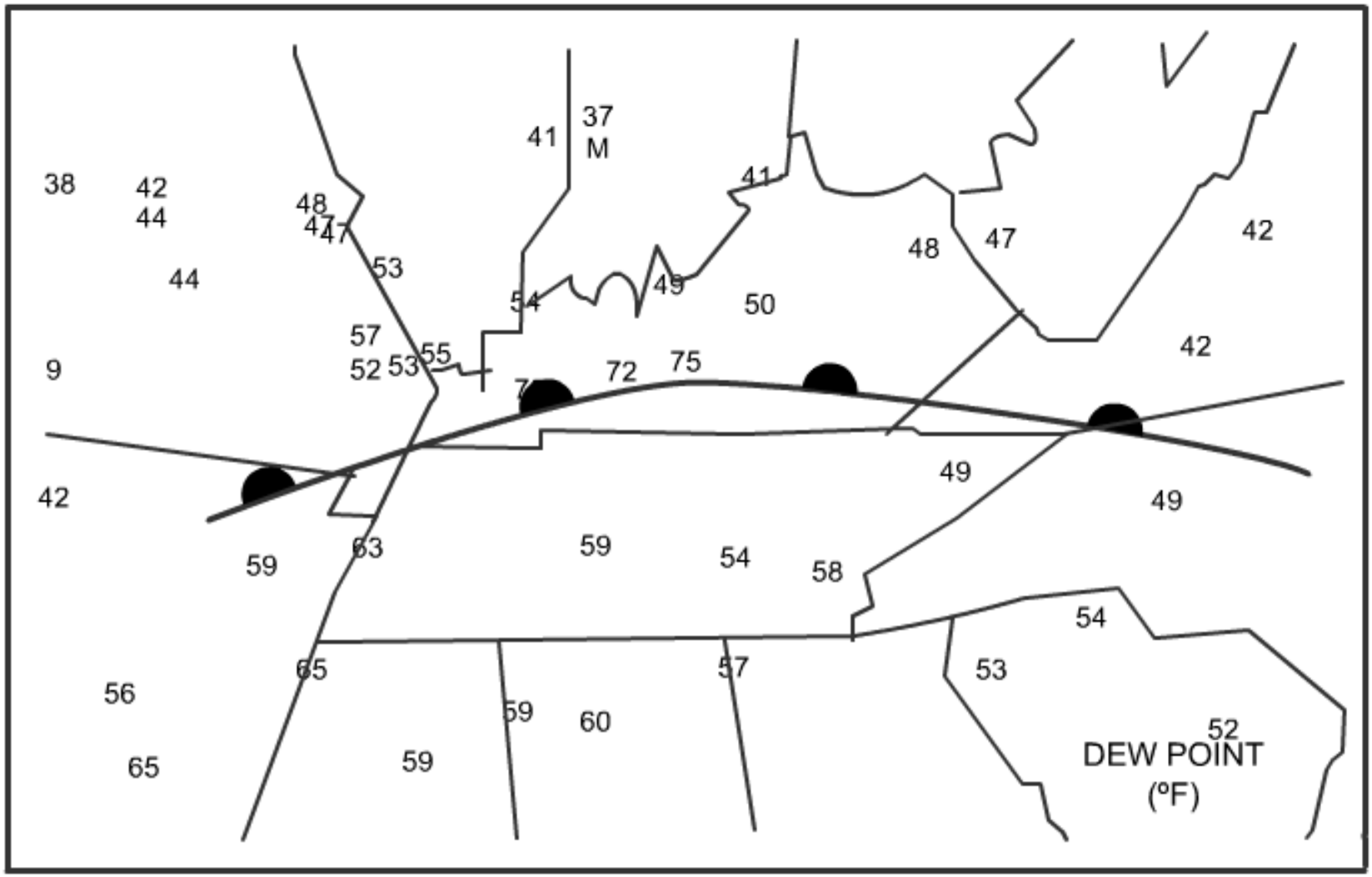
- 3 Moisture discontinuity exists across frontal surface.
  - » Air behind (i.e., on warm side of) warm front typically has higher dew point, but lower relative humidity
    (1) Dewpoint increases with FROPA.
    (2) Farther from saturation in warm air because of the larger spread between temperature and dew point.

Types of Fronts

» Air ahead (i.e., on cold side) of warm front normally nearer to saturation (i.e., relative humidity near 100%) even though dew point is lower.

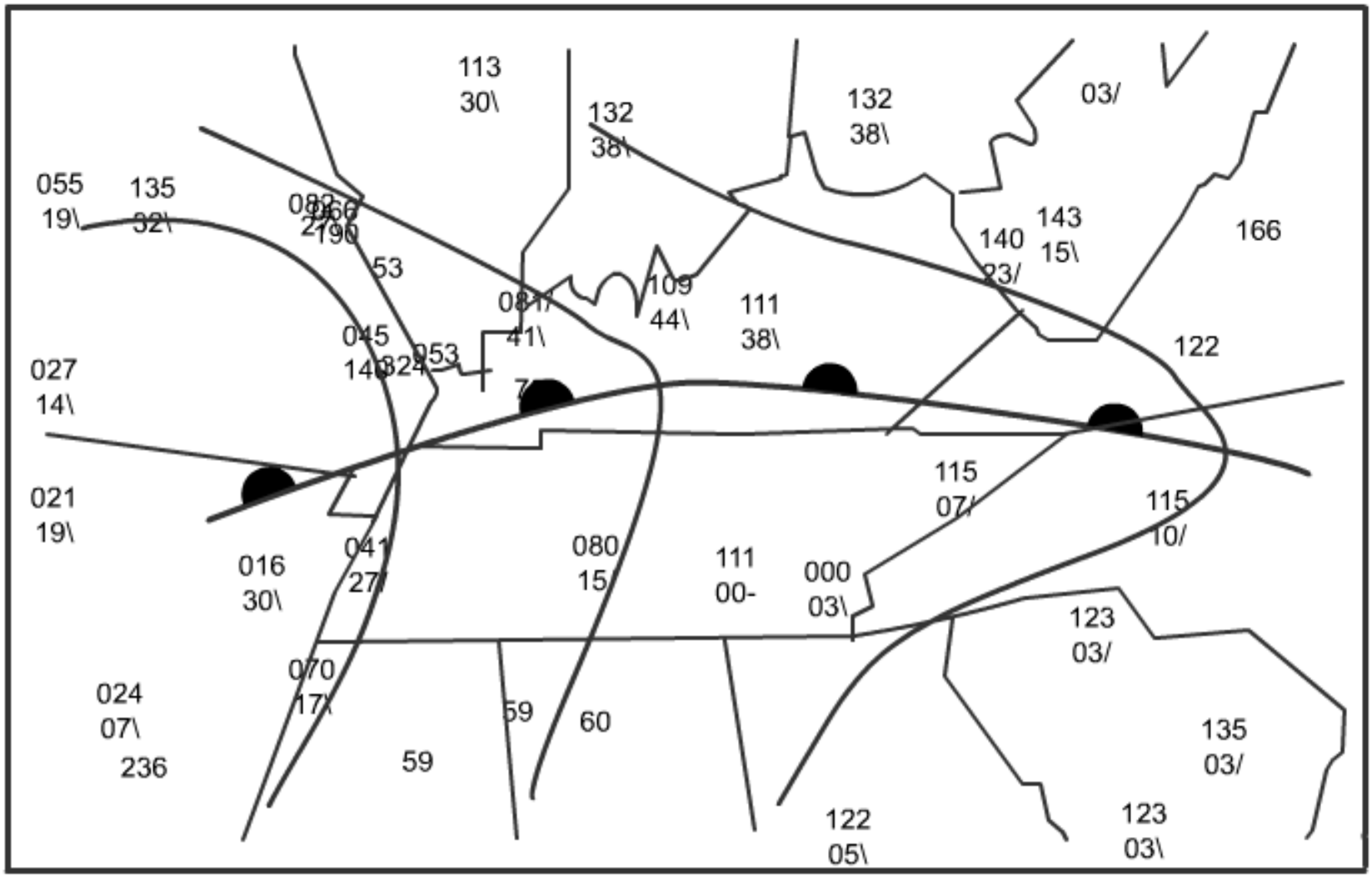
(1) Evaporation due to falling precipitation from warmer layer aloft through shallow cold layer.

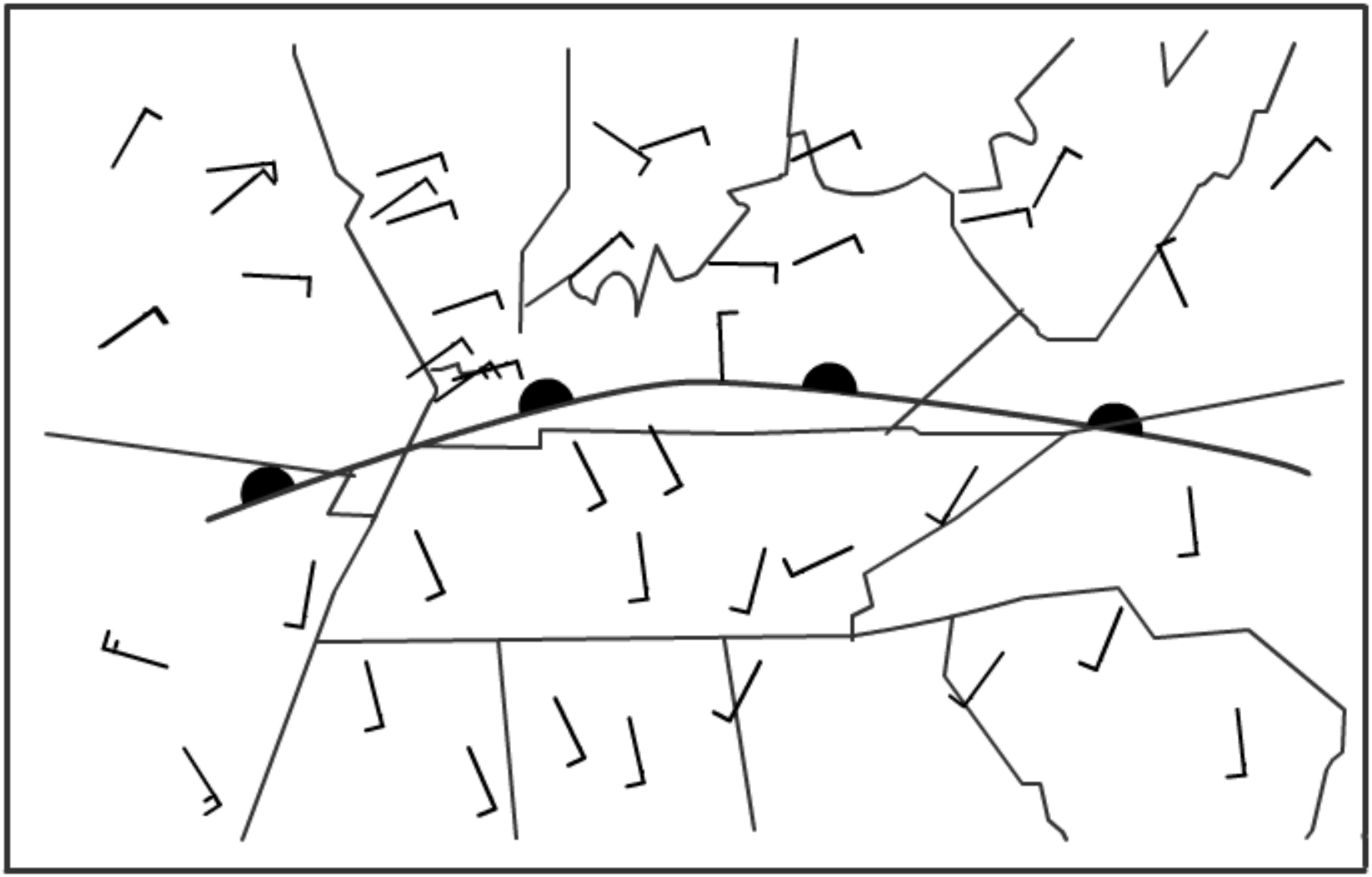
(2) Evaporation raises dew point rises to temperature, producing very low clouds and evaporation fog.


38
42
44
44
48
47
47
53
41
37
M
54
49
50
41
48
47
42
57
52
53
55
9
72
75
42
49
42
49
59
63
59
54
58
54
65
57
53
56
59
60
65
59
52
DEW POINT
(ºF)

Types of Fronts

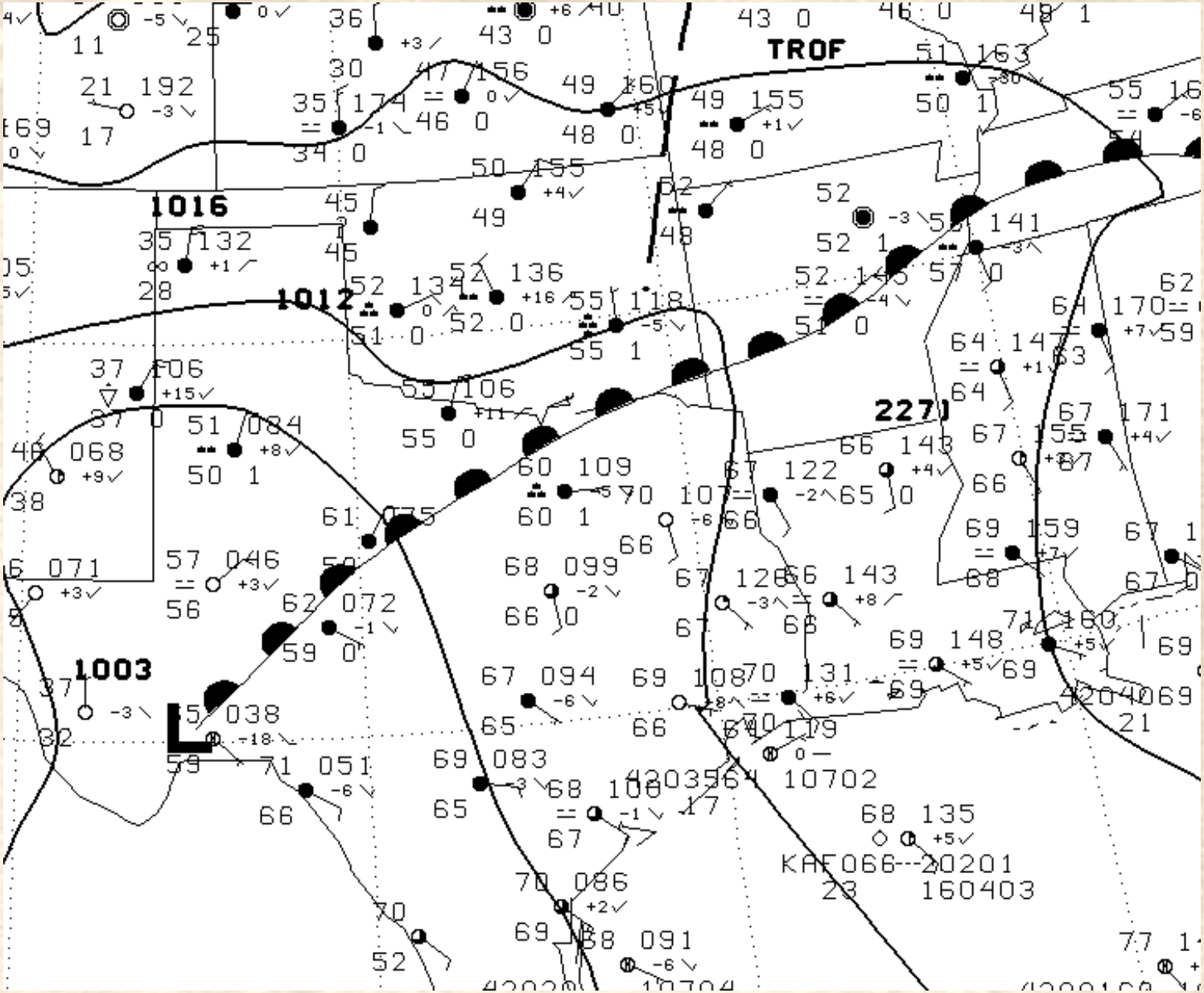
- Pressure tendencies associated with a warm front:
  - » Strong pressure falls (PRESFR) observed ahead of surface front
  - » Pressure behind surface front may fall slowly, rise slowly, or remain steady

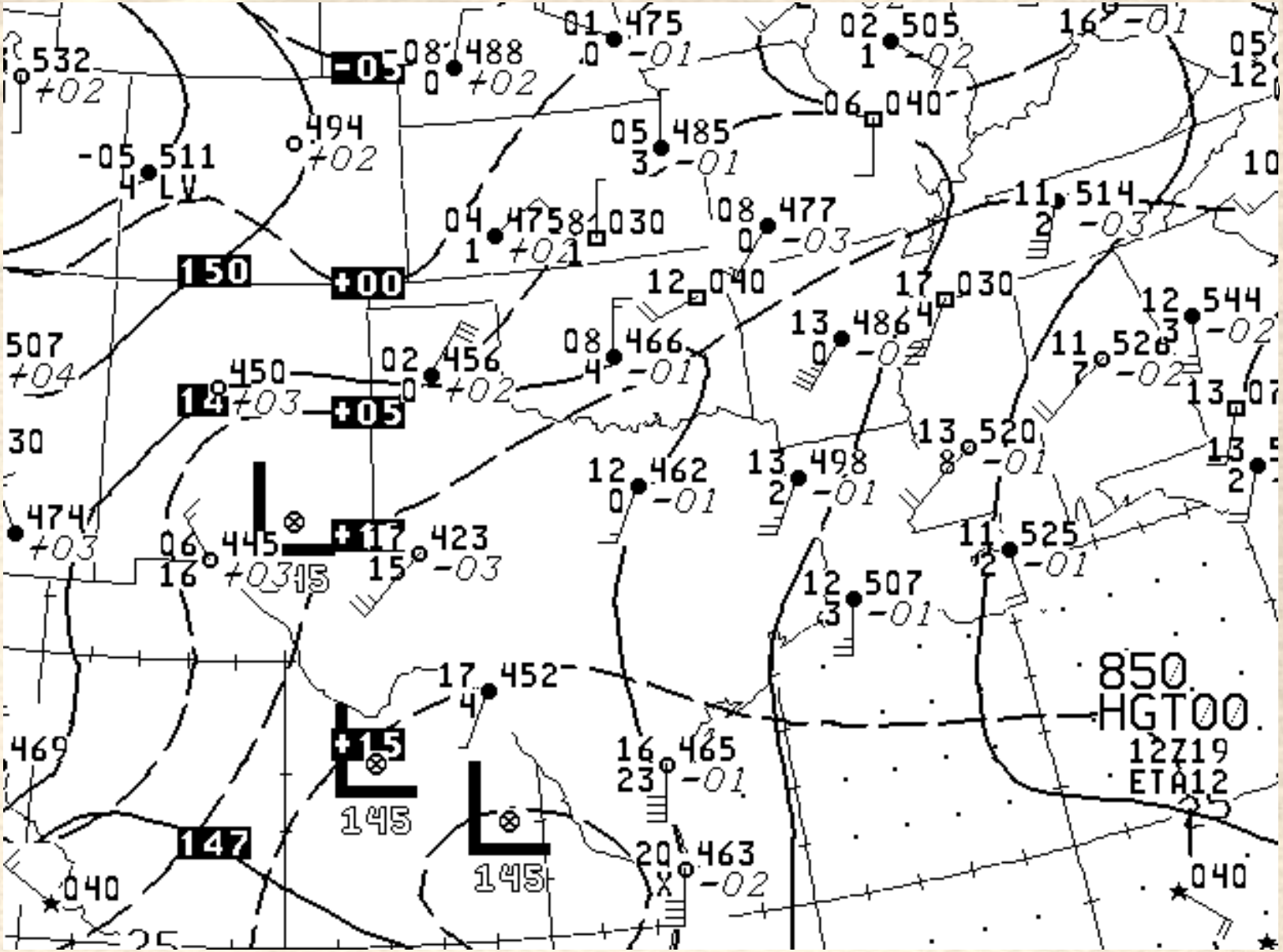

113
30\
132
38\
132
38\
03/
055
19\
135
32\
190
53
140
23/
143
15\
166
109
44\
111
38\
122
027
14\
045
14
053
115
07/
115
10/
021
19\
016
30\
041
27/
080
15
111
00-
000
03\
123
03/
070
17\
024
07\
236
59
60
59
135
03/
122
05\
123
03\

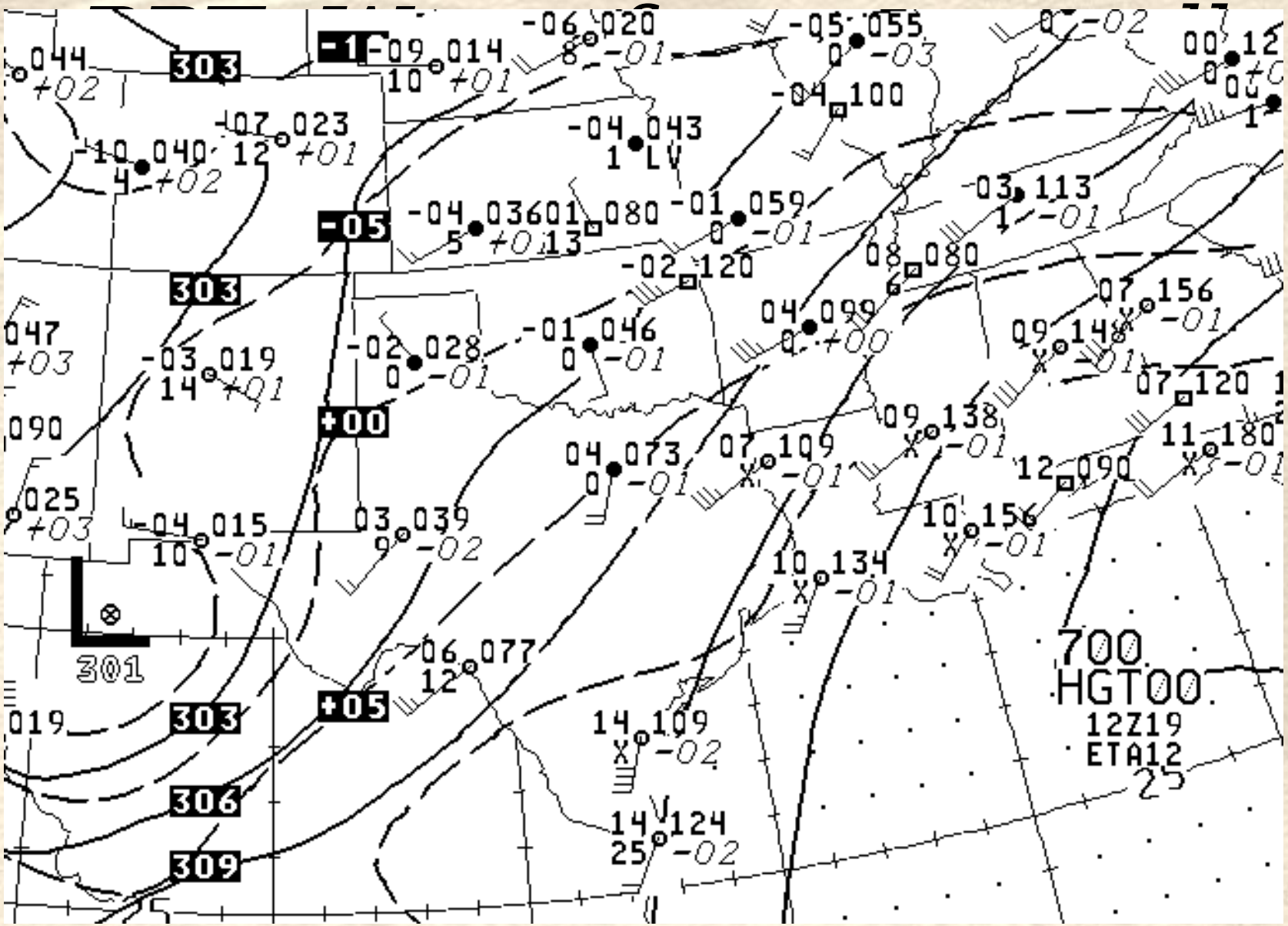


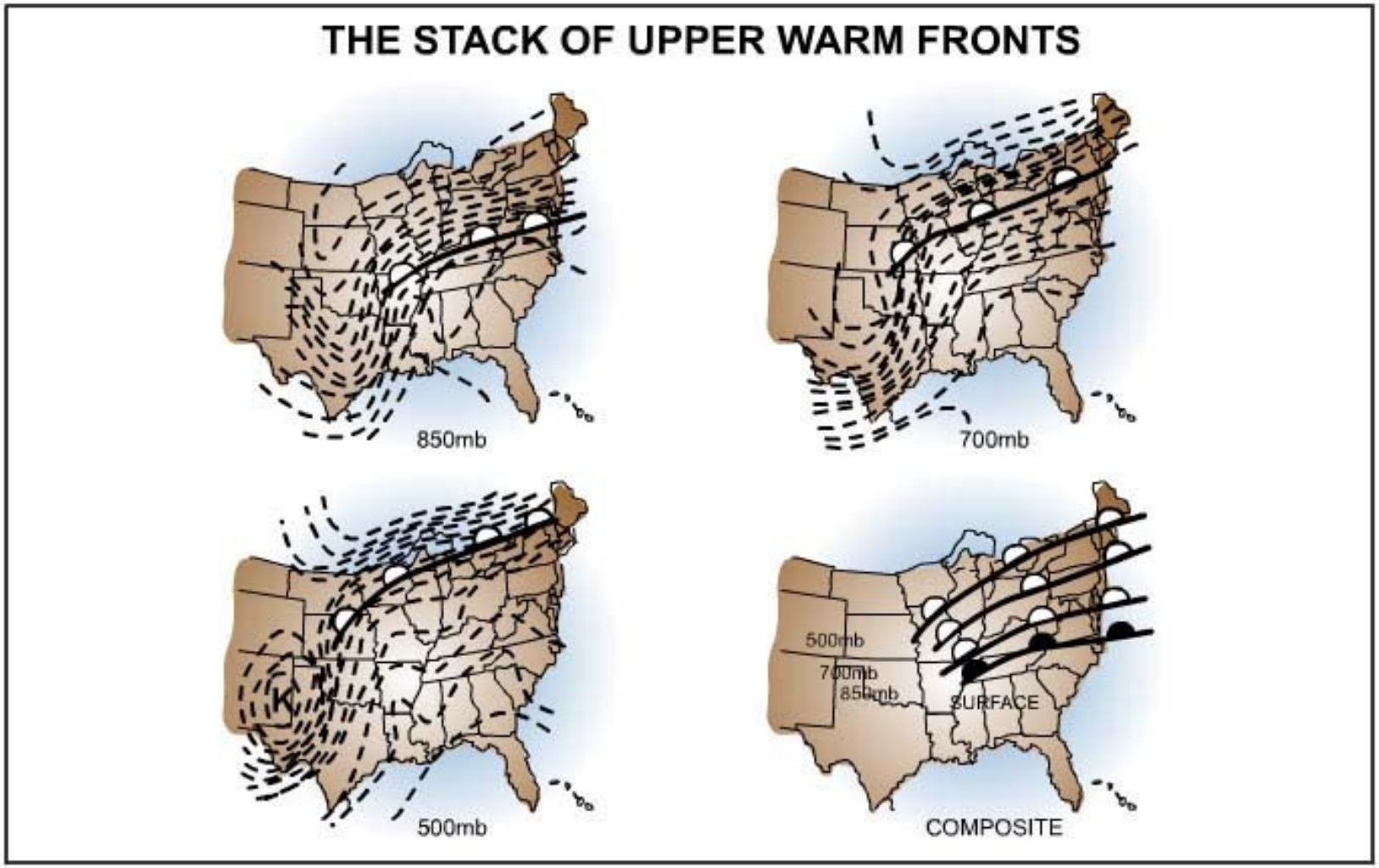
Types of Fronts

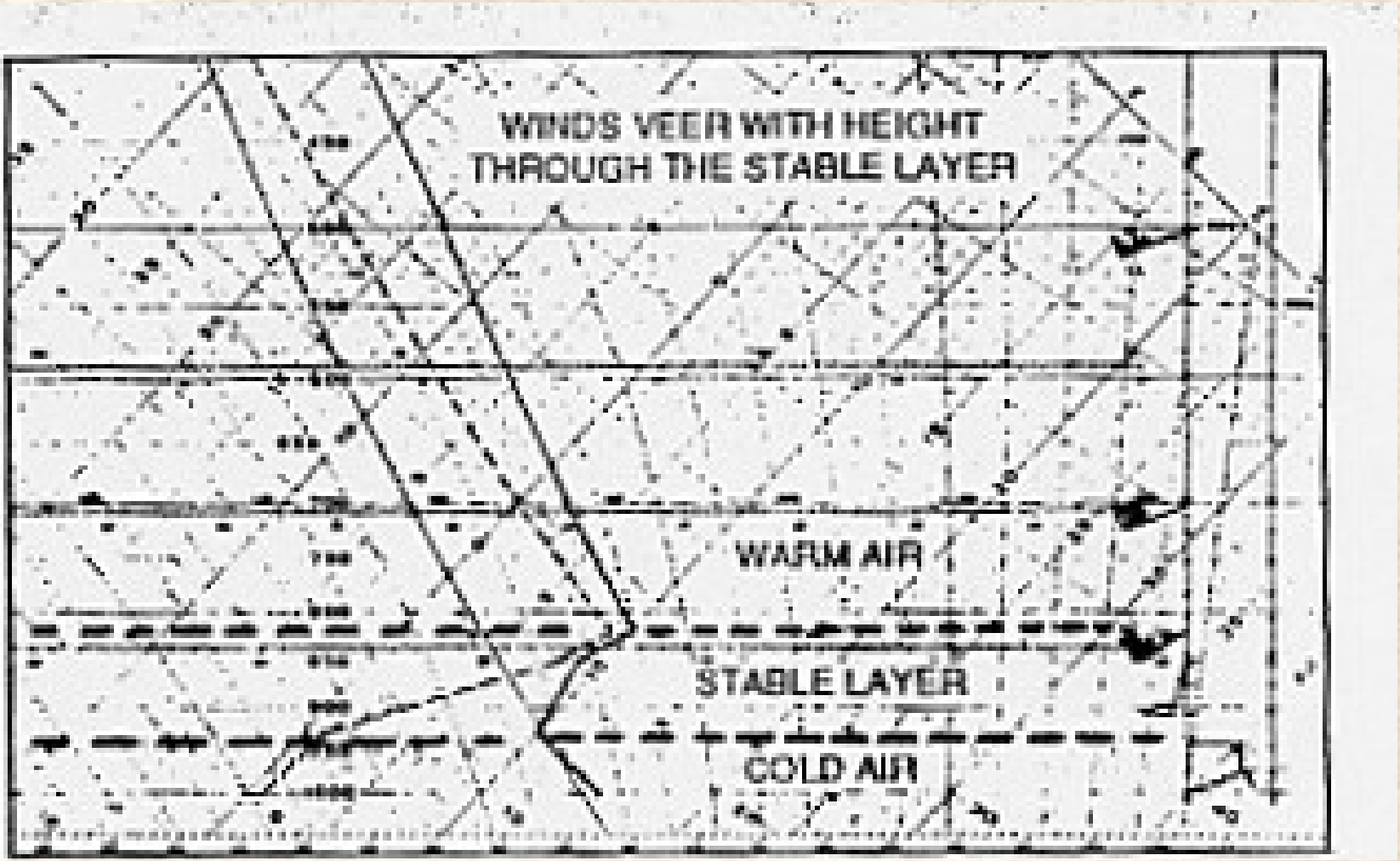
- Vertical
  - Frontal surface slopes over colder air mass.
  - Normally above 850 mb, a well defined frontal trough will not be found.
    - » Strong fronts with steep slopes may be clearly defined up through 500 mb.
    - » Weak fronts with shallow slopes are normally best defined at 850 mb and below.
    - » A RAOB sounding originating on cold side of surface front will exhibit veering winds within the frontal inversion stable layer, indicative of warm advection.


TROF
1016
1012
1003
2270


850
HGT00
12Z19
ETA12


700
HGT00
12Z19
ETA12
25


THE STACK OF UPPER WARM FRONTS
850mb
700mb
500mb
500mb
700mb
850mb
SURFACE
COMPOSITE


WINDS VEER WITH HEIGHT
THROUGH THE STABLE LAYER
WARM AIR
STABLE LAYER
COLD AIR

Types of Fronts

- Warm Front Characteristics
  - Movement - generally slower than a cold front
    - Influenced strongly by the speed that the colder air mass retreats.

      Lower-tropospheric warm advection has a large influence on the movement of the warm front and the strength of upward vertical motion via “overrunning” (i.e., isentropic uplift).

Types of Fronts

» Lower tropospheric warm advection is a Q-G Omega Equation lifting mechanism. As warm air is lifted, it undergoes adiabatic cooling, which then partially offsets the warming produced by the physical movement of warm air into the region. Thus, in a simplistic view:

(1) If all the warm advection goes into horizontal movement of warm air from one location to another, no vertical motion occurs, but the warm front moves quickly.

(2) If all the warm advection goes into vertical motion of warm air upward, no horizontal temperature increase will be realized and the front will not move.

Types of Fronts

(3) Application of this simplistic relationship results in the following associations:

a. If warm front is moving quickly

(1) Little lift along the front

(2) Little or no precipitation occurs.

b. If warm front is moving slowly

(1) Significant overrunning may occur.

(2) Widespread precipitation may occur.

These rules are overly simplistic and should be used with great caution. They are easily overcome by terrain influences, diabatic effects, and frontogenetic jet stream influences. Computer forecast models should be smartly utilized in frontal motion forecasting whenever possible.

Types of Fronts

» Warm advection also promotes surface pressure falls, thereby aiding the progression of the low pressure system.

Types of Fronts

- Vertical structure of active warm fronts are, in many ways, similar to slow-moving active cold fronts (discussed earlier).
  - » Both have significant warm advection "overrunning".
  - » Both have expansive cloudiness and precipitation shields on their cold side
  - » However, they differ mainly in the direction in which they move.

    (1) Cold fronts advance toward warmer air (i.e., cold advection prevails).

    (2) Warm fronts advance toward colder air (i.e., warm advection prevails).

Types of Fronts

- As with cold fronts, warm front lifting is greatly affected by the presence or absence of jet stream divergence and the stability and moisture content of the warmer air mass. Topographical effects, such as mountains, are also important.
- Classic warm front cloud sequence is Ci, Cs, As, Ns, St/fog.

Types of Fronts

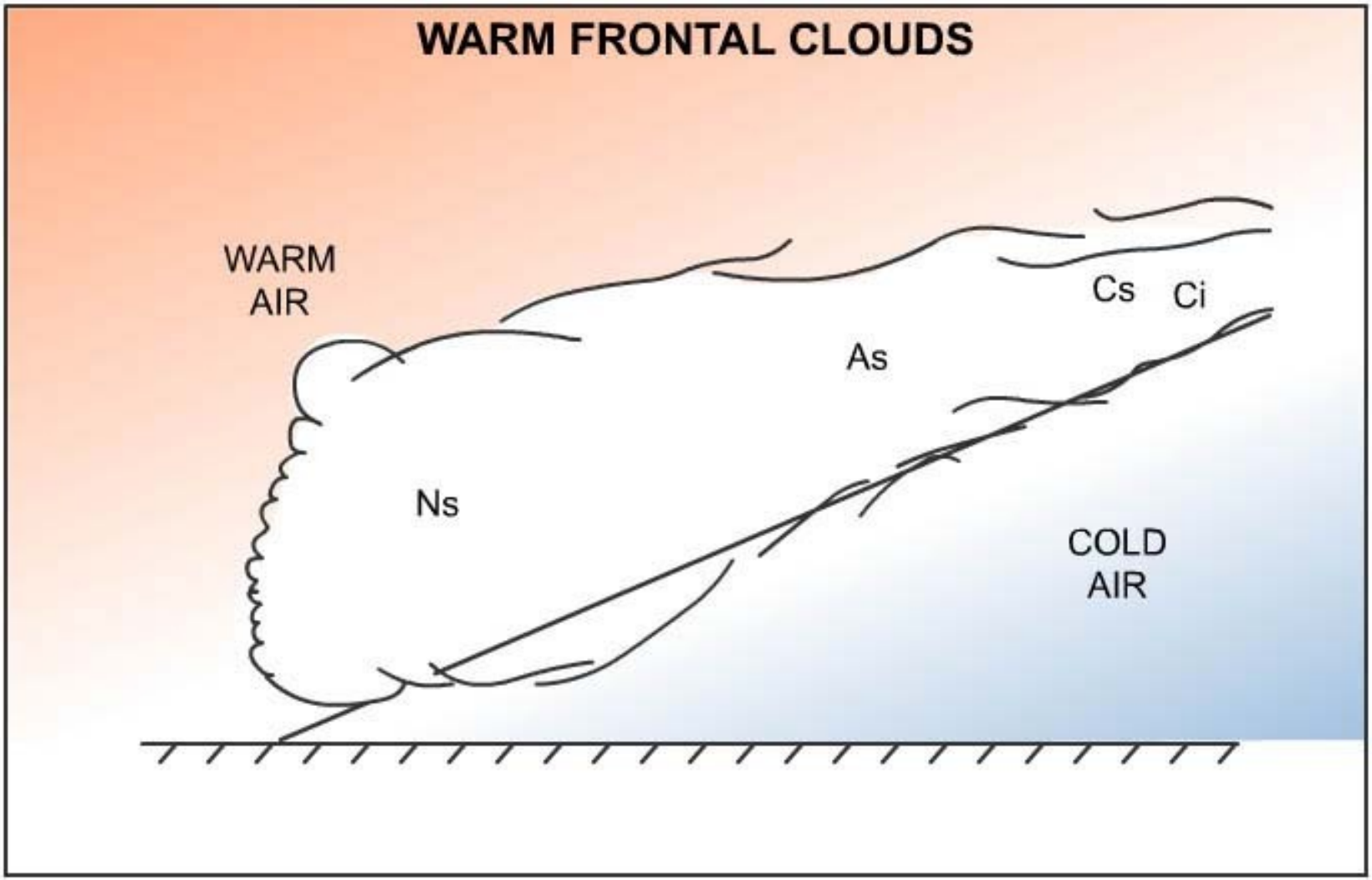
- Precipitation type depends on time of year and the vertical temperature profile on the cold side of the front.
  - » If the temperature of cold air mass is below freezing, and:

    (1) Air is below freezing throughout the entire tropospheric column, snow falls well in advance of front.

    (2) Elevated warm layer above frontal inversion melts falling snow aloft, then the melted precipitation falls through a relatively thick surface cold layer and freezes into ice pellets (i.e., sleet).

Types of Fronts

(3) The same sequence occurs as in b except the surface cold layer is relatively thin, then freezing rain will develop as water becomes super-cooled immediately prior to reaching the surface.


WARM FRONTAL CLOUDS
WARM
AIR
Cs
Ci
As
Ns
COLD
AIR

Types of Fronts

» Rain and/or drizzle occur near front where surface air (and the wet bulb temperature) is above freezing.

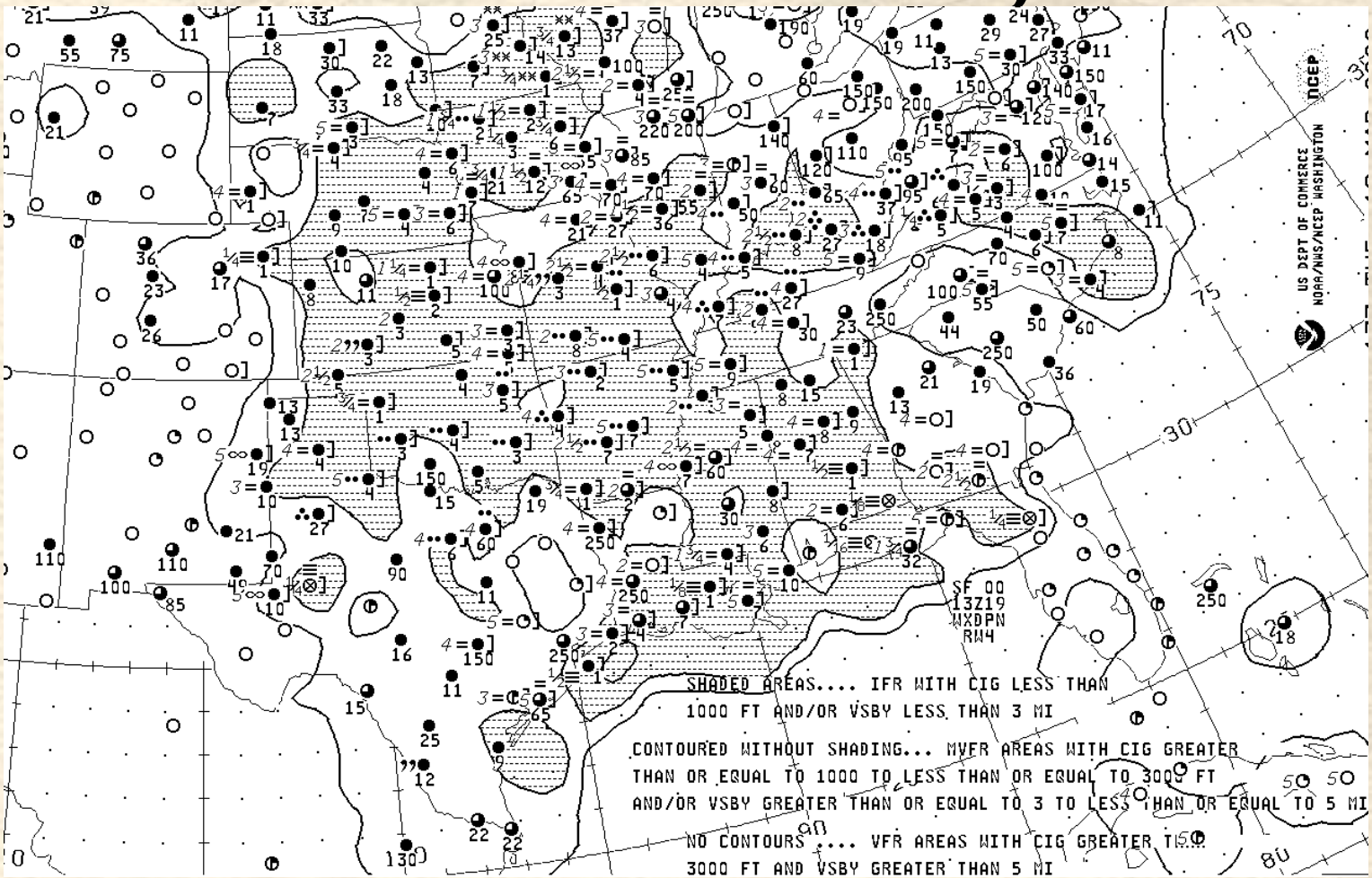
» Temperature and wet bulb temperature of cold air mass is above freezing, expect extensive area of light rain ahead of front.

(1) Fog is often observed near the front.

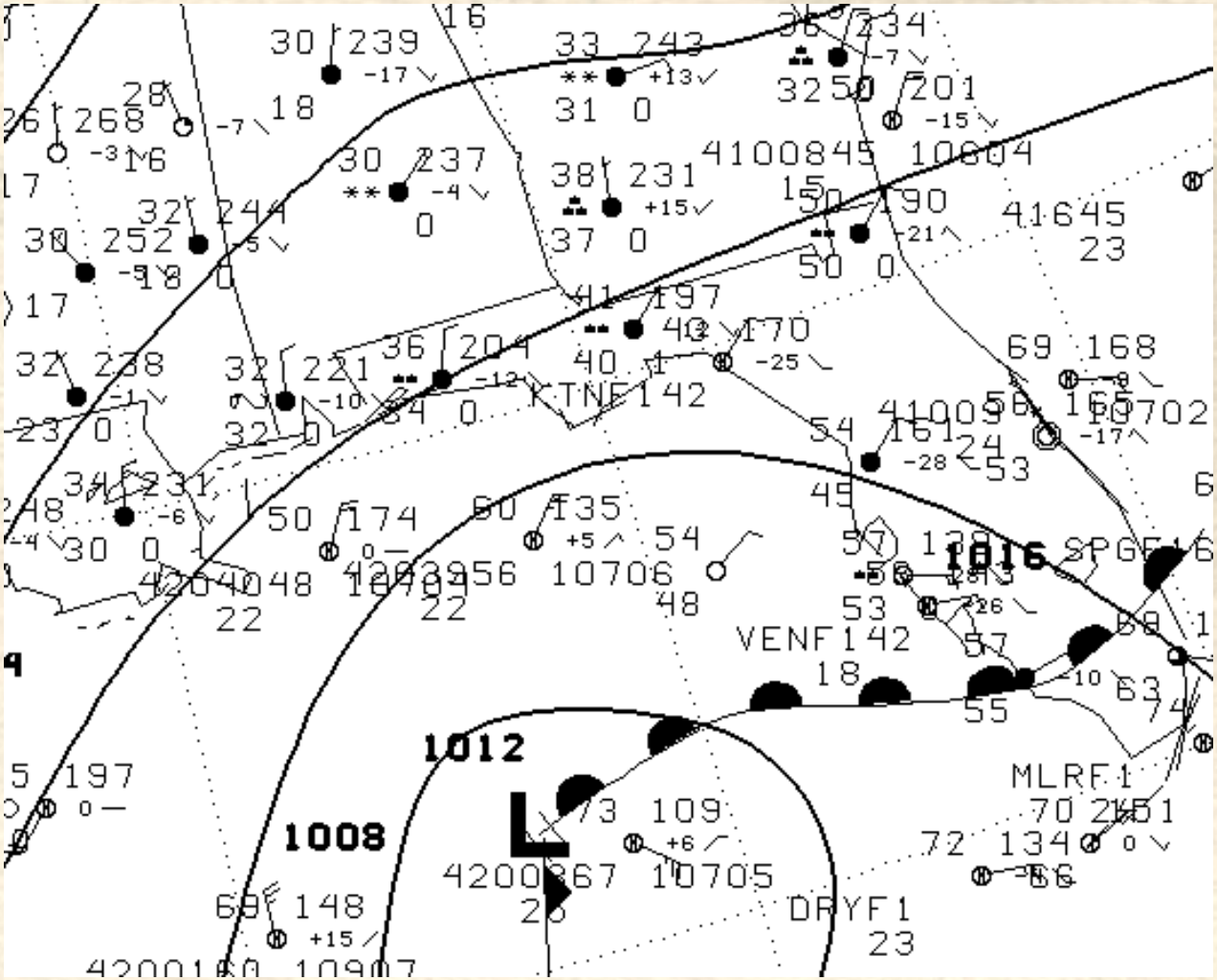
(2) If warmer air is dry, or upward vertical motion is weak, only high cloudiness may be present.

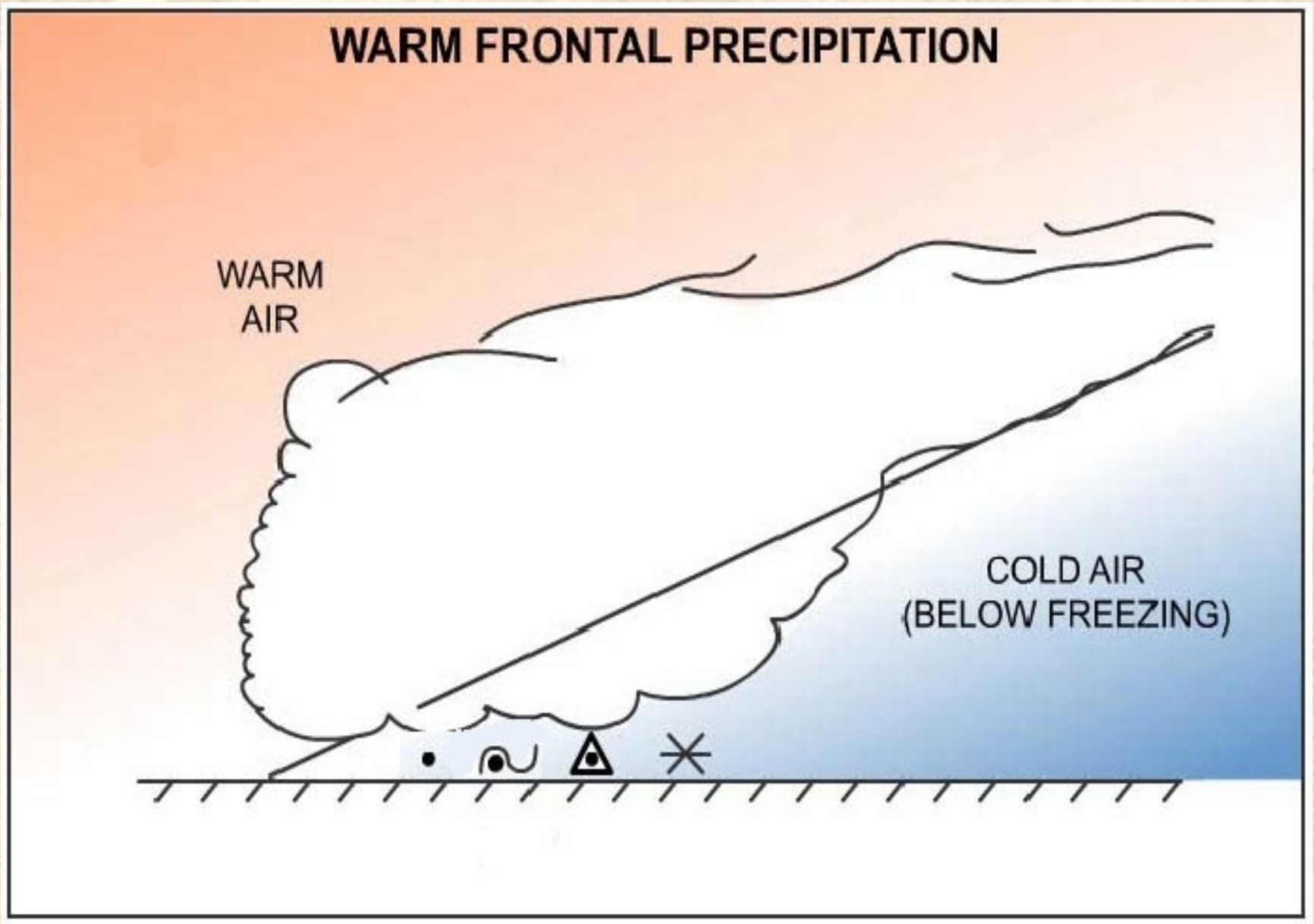
– Some warm fronts are inactive, due to lack of moisture, air mass stability, and/or lack of lift from temperature advection, and/or upper level jet stream/trough divergence

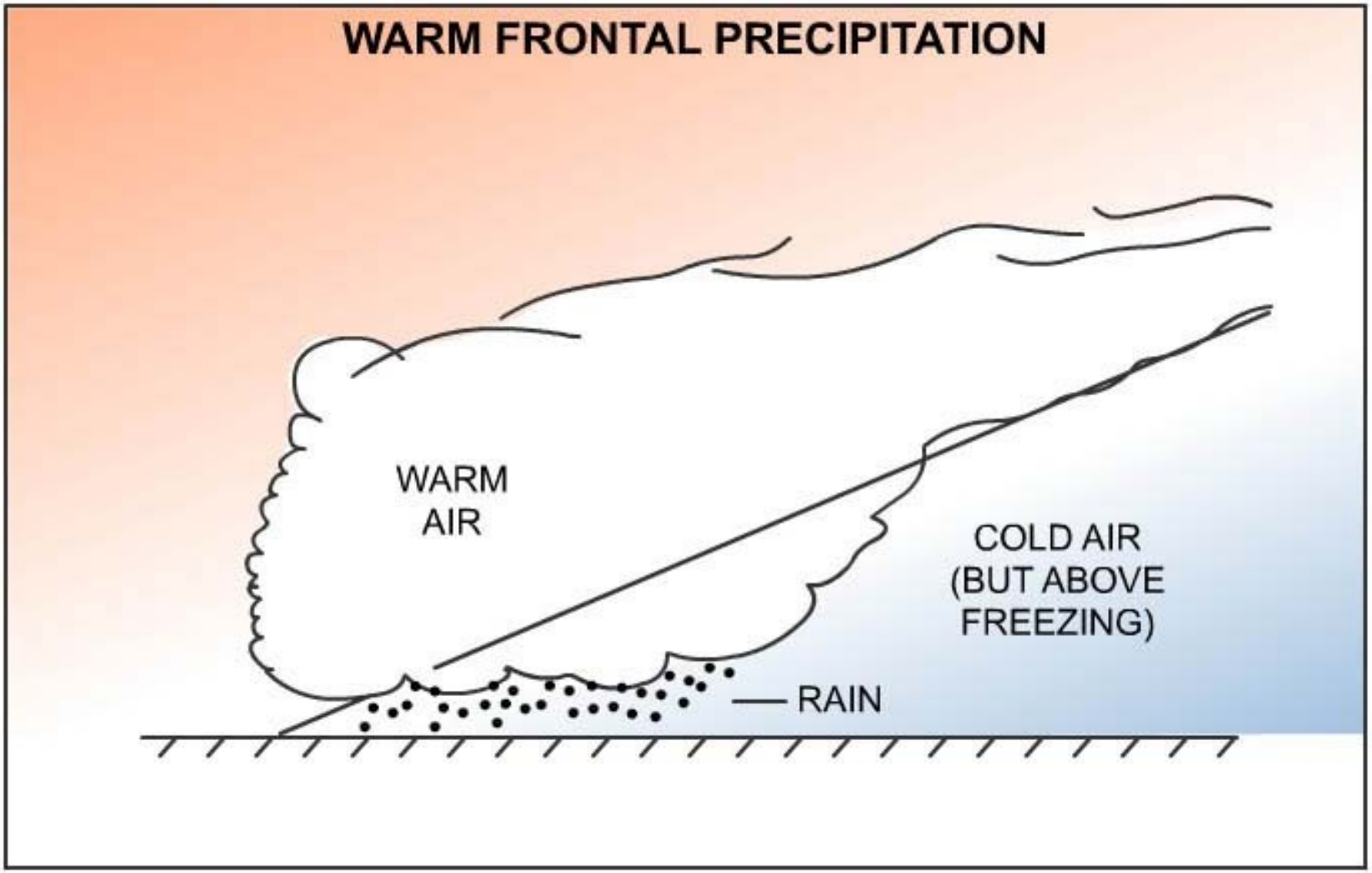
Weather, ceilings, vsby assoc with warm front


US DEPT OF COMMERCE
NOAA/NWS/NCEP WASHINGTON
NCEP
SF 00
13Z19
WXDPN
RW4
SHADED AREAS.... IFR WITH CIG LESS THAN
1000 FT AND/OR VSBY LESS THAN 3 MI
CONTOURED WITHOUT SHADING... MVFR AREAS WITH CIG GREATER
THAN OR EQUAL TO 1000 TO LESS THAN OR EQUAL TO 3000 FT
AND/OR VSBY GREATER THAN OR EQUAL TO 3 TO LESS THAN OR EQUAL TO 5 MI
NO CONTOURS .... VFR AREAS WITH CIG GREATER THAN
3000 FT AND VSBY GREATER THAN 5 MI

Transition of precipitation




WARM FRONTAL PRECIPITATION
WARM
AIR
COLD AIR
(BELOW FREEZING)

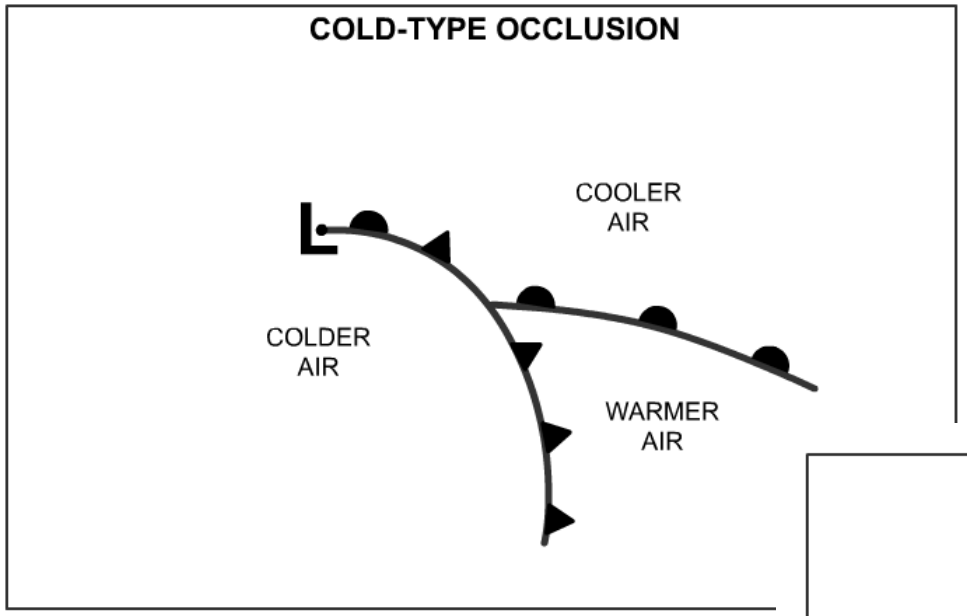

WARM FRONTAL PRECIPITATION
WARM
AIR
COLD AIR
(BUT ABOVE
FREEZING)
RAIN

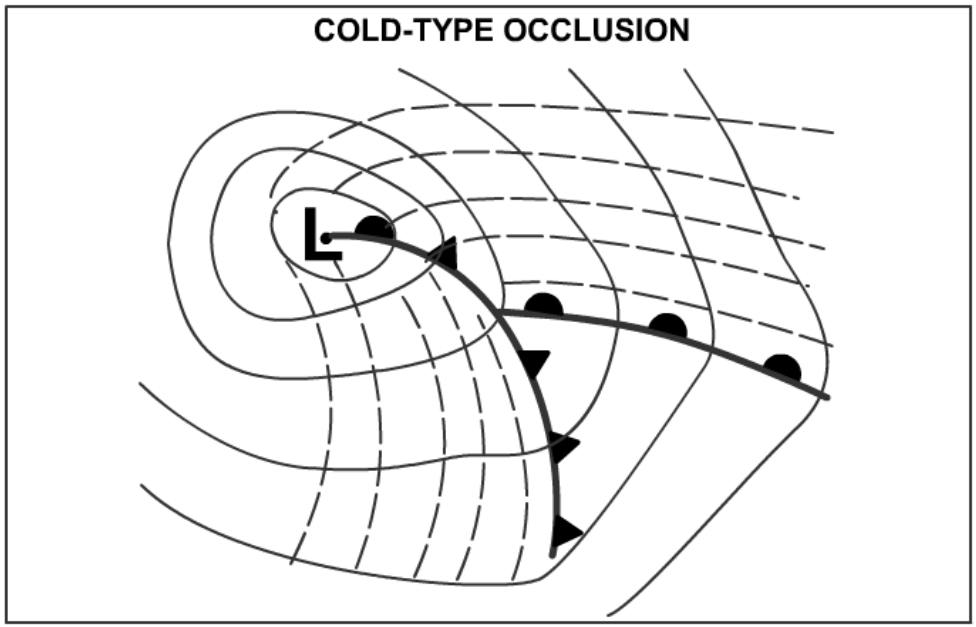
Types of Fronts

- Occluded Fronts
  - Occluded fronts are completely embedded within cold air at the surface. Warmer air resides aloft over the cold surface air. Research continues into how occluded fronts actually evolve. For the sake of simplicity, the classic conceptual evolution of cold and warm occlusions is discussed. However, more recently, research suggests that *"instant"* occlusions represent a third type of occluded front. Keep in mind that there is no perfect model for occlusions and that the atmosphere displays many variations of the three types discussed below. Careful evaluation of analysis products and numerical model forecasts can greatly aid interpretation of occluded fronts.

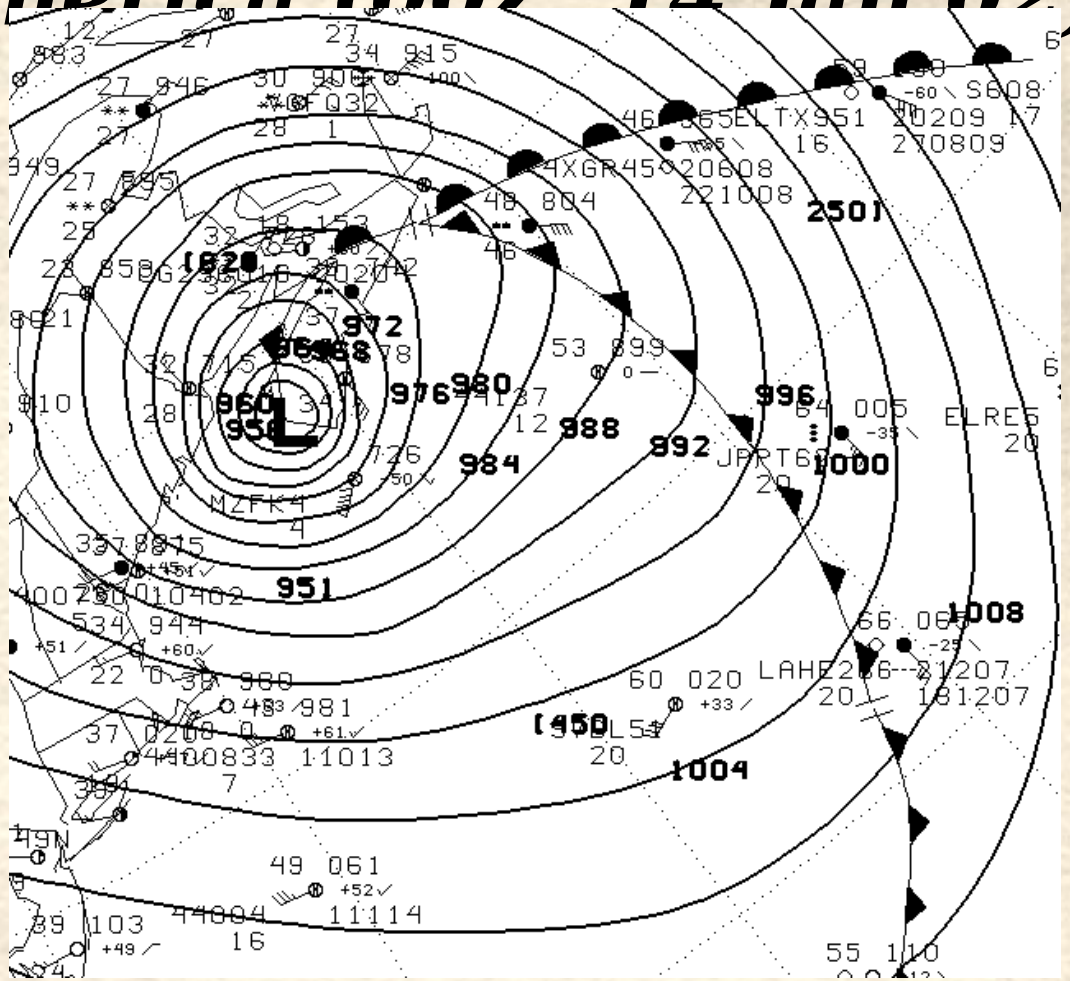
Types of Fronts

- Cold Type Occlusion
  - Coldest air found behind occlusion
  - Normally located within thermal ridge on thickness chart
  - Appear on surface as extension of cold front poleward of warm front position
  - Forms when cold air overtakes warm front
    - » Lifts warm air residing above warm front
    - » Lifts cool air residing beneath of warm front

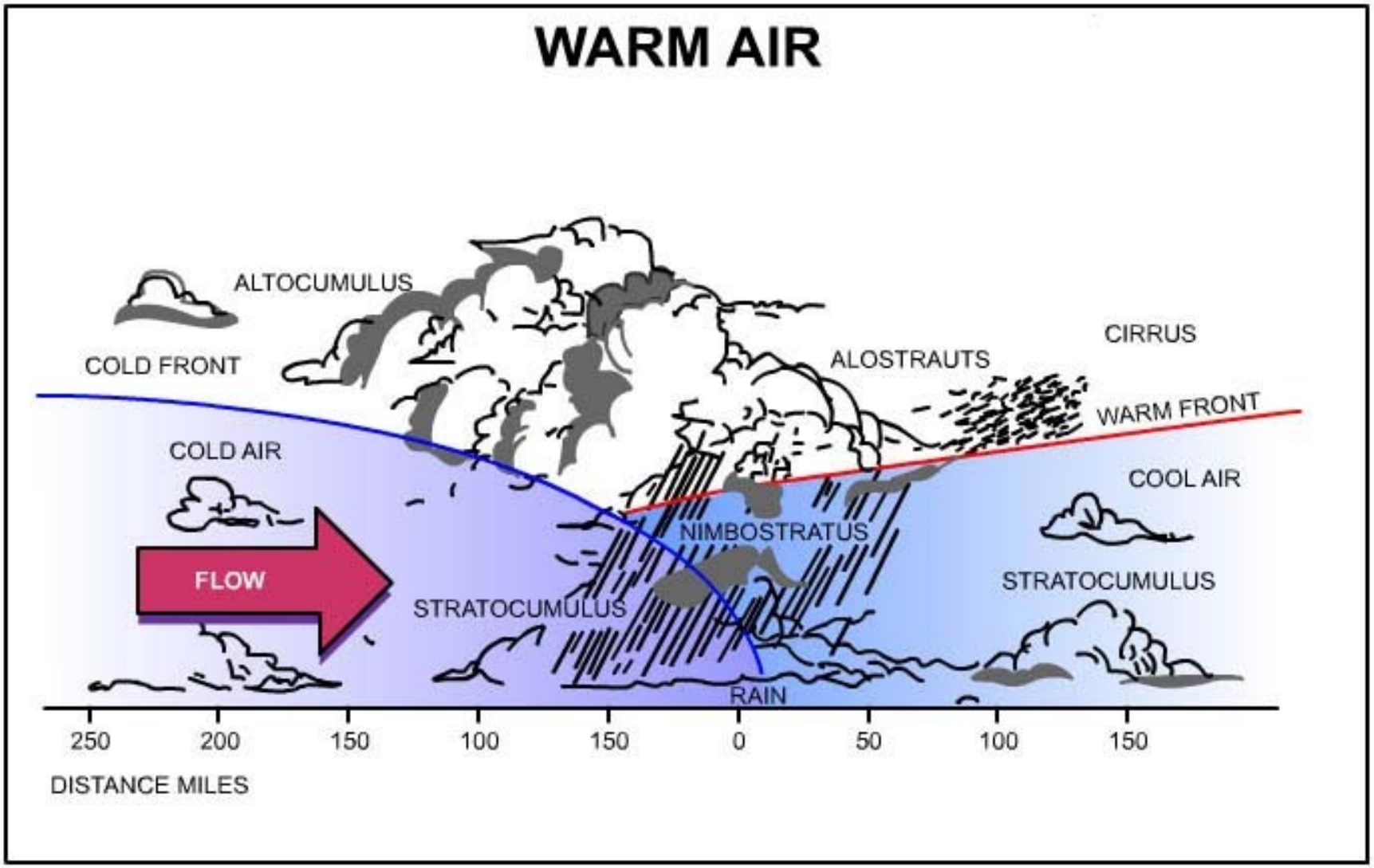

COLD-TYPE OCCLUSION
COOLER
AIR
COLDER
AIR
WARMER
AIR


COLD-TYPE OCCLUSION

Example of a Cold Occlusion over the East Coast of North America (00Z, 14 Jan 02)



PPT: Cold Type



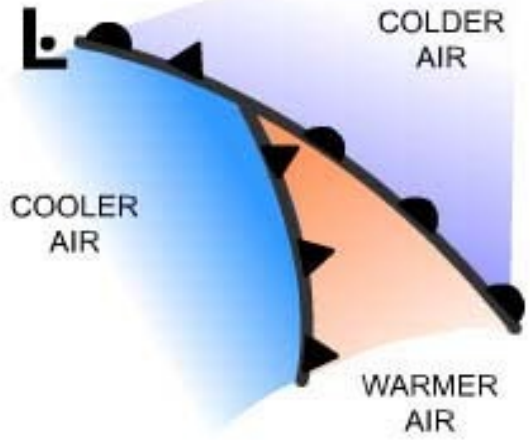
Types of Fronts

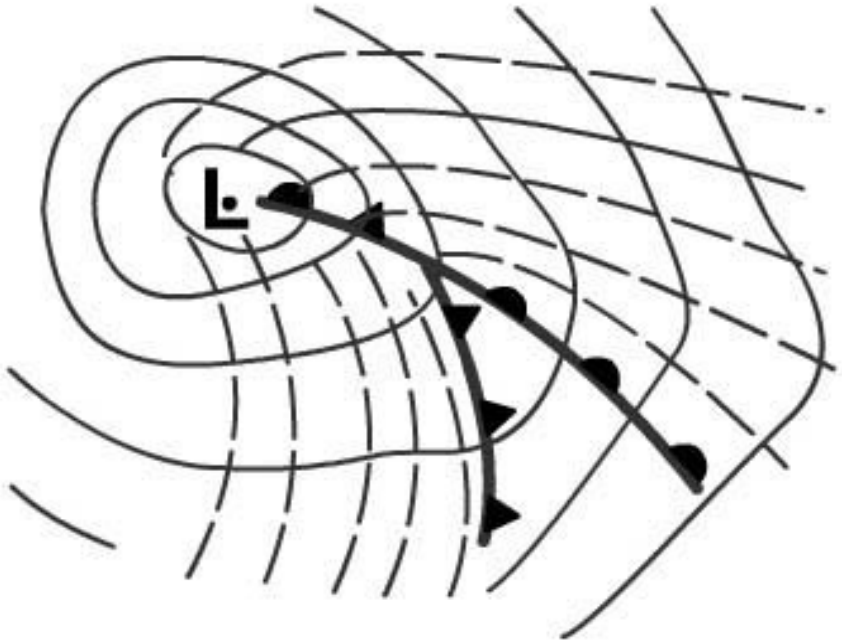
- Quite common over eastern portions of continents/western oceans in winter
- May be found along west coast of continents in summer

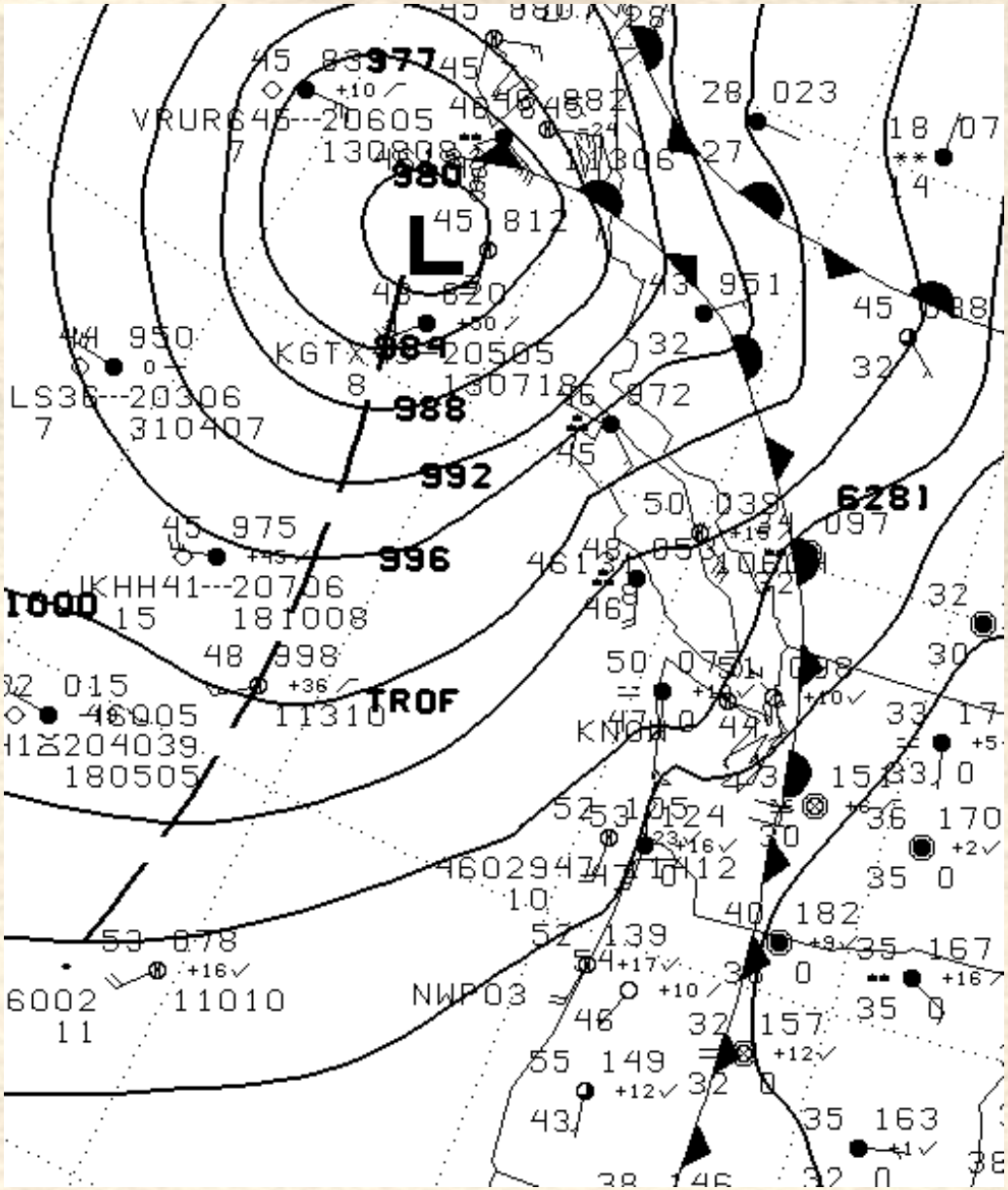
Types of Fronts

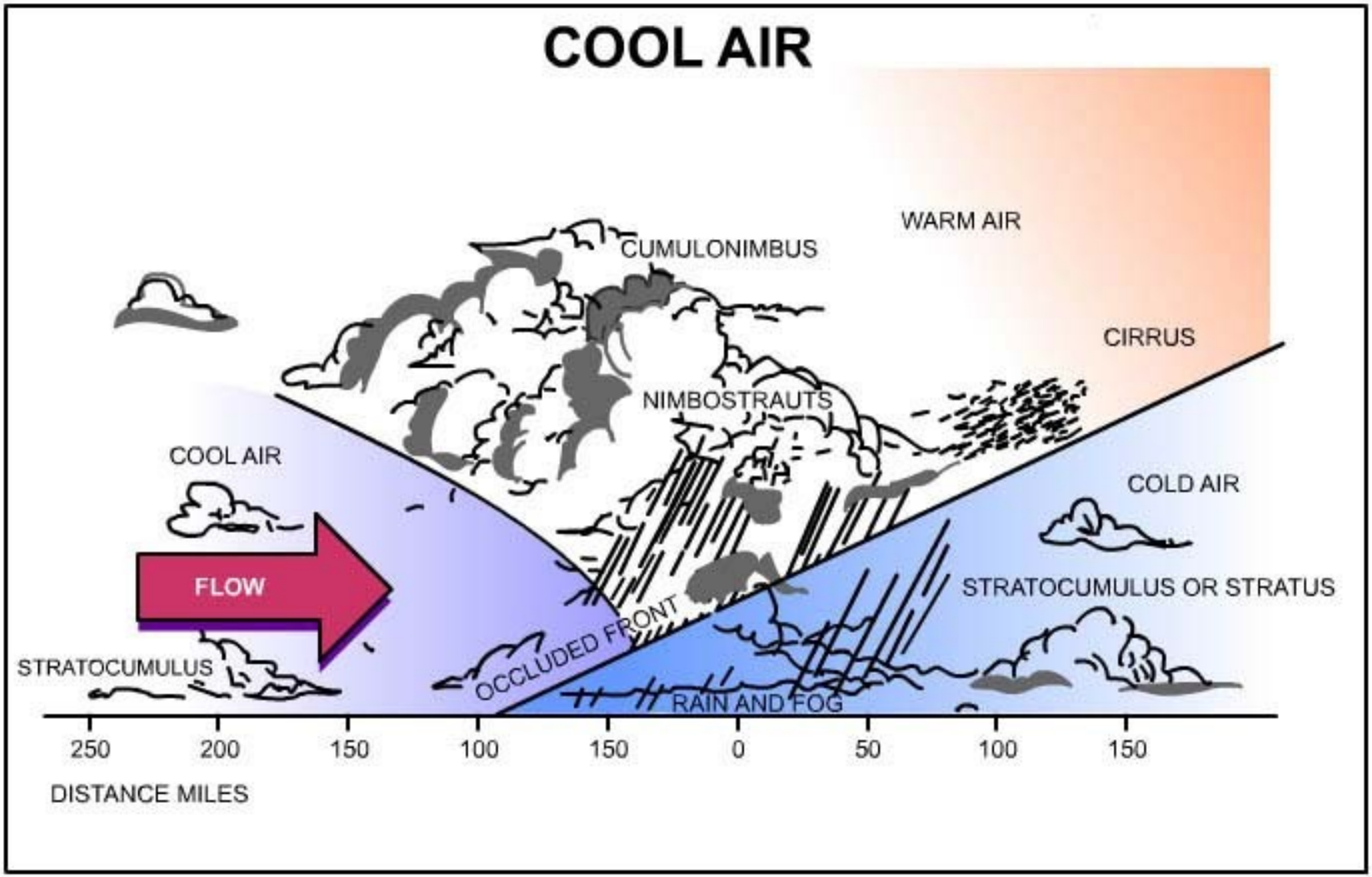
- Warm Type Occlusion
  - Coldest air found ahead of occlusion
  - Normally located behind thermal ridge on thickness
  - Appears as extension of warm front, poleward of surface cold front
  - Forms where cold front and cool air behind it are forced aloft, over warm frontal surface

WARM-TYPE OCCLUSION






977
980
L
984
988
992
996
1000
TROF
6281
VRUR645---20605
KGTX 20505
LS36---20306
KHH41---20706
KNCA
NWP03


COOL AIR
WARM AIR
CUMULONIMBUS
CIRRUS
NIMBOSTRAUTS
COOL AIR
COLD AIR
FLOW
STRATOCUMULUS OR STRATUS
OCCLUDED FRONT
STRATOCUMULUS
RAIN AND FOG
250
200
150
100
150
0
50
100
150
DISTANCE MILES

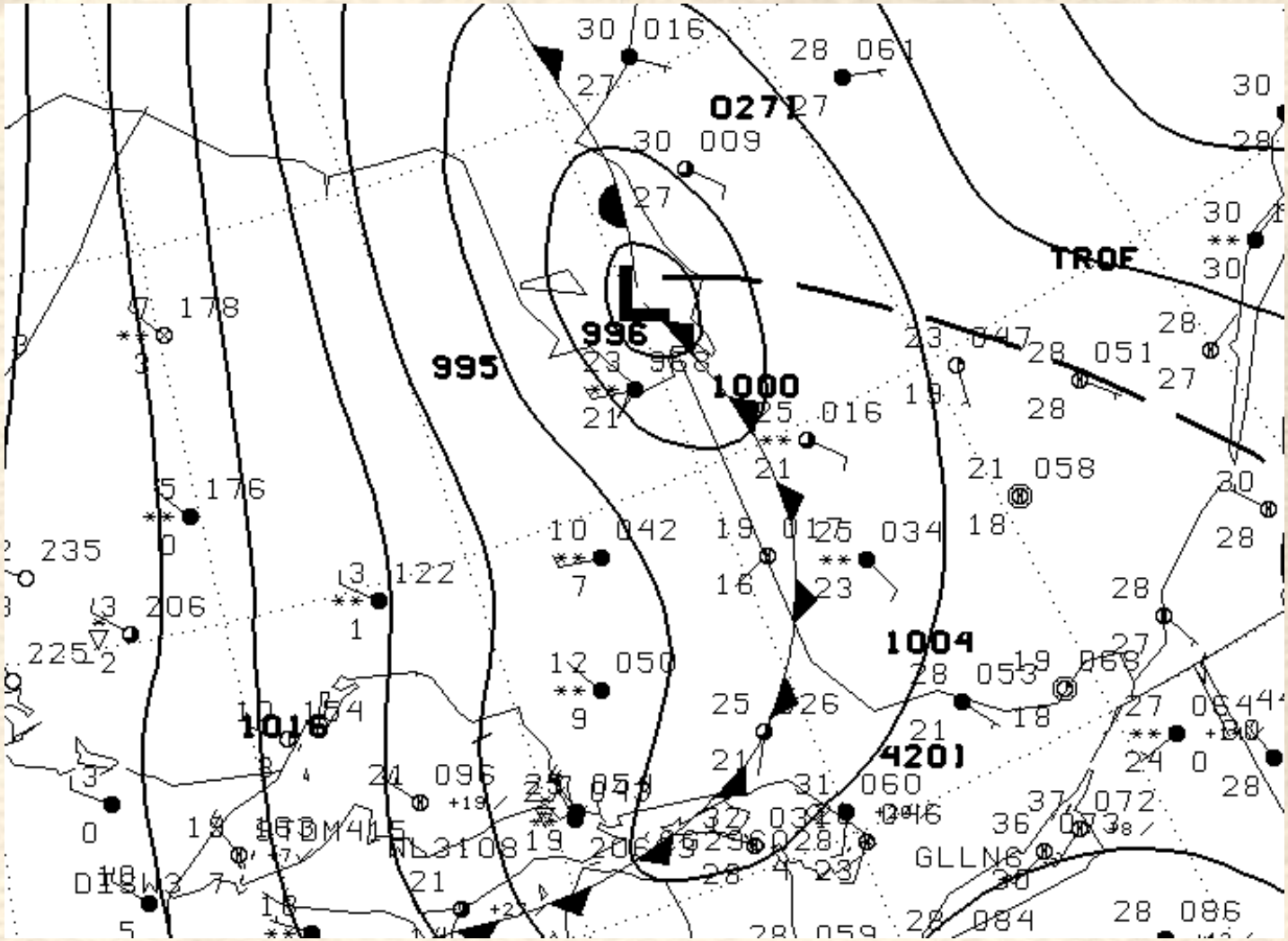
Types of Fronts

- Quite common over western portions of continents/eastern oceans in winter
- May be found along east coasts of continents/western oceans in summer.

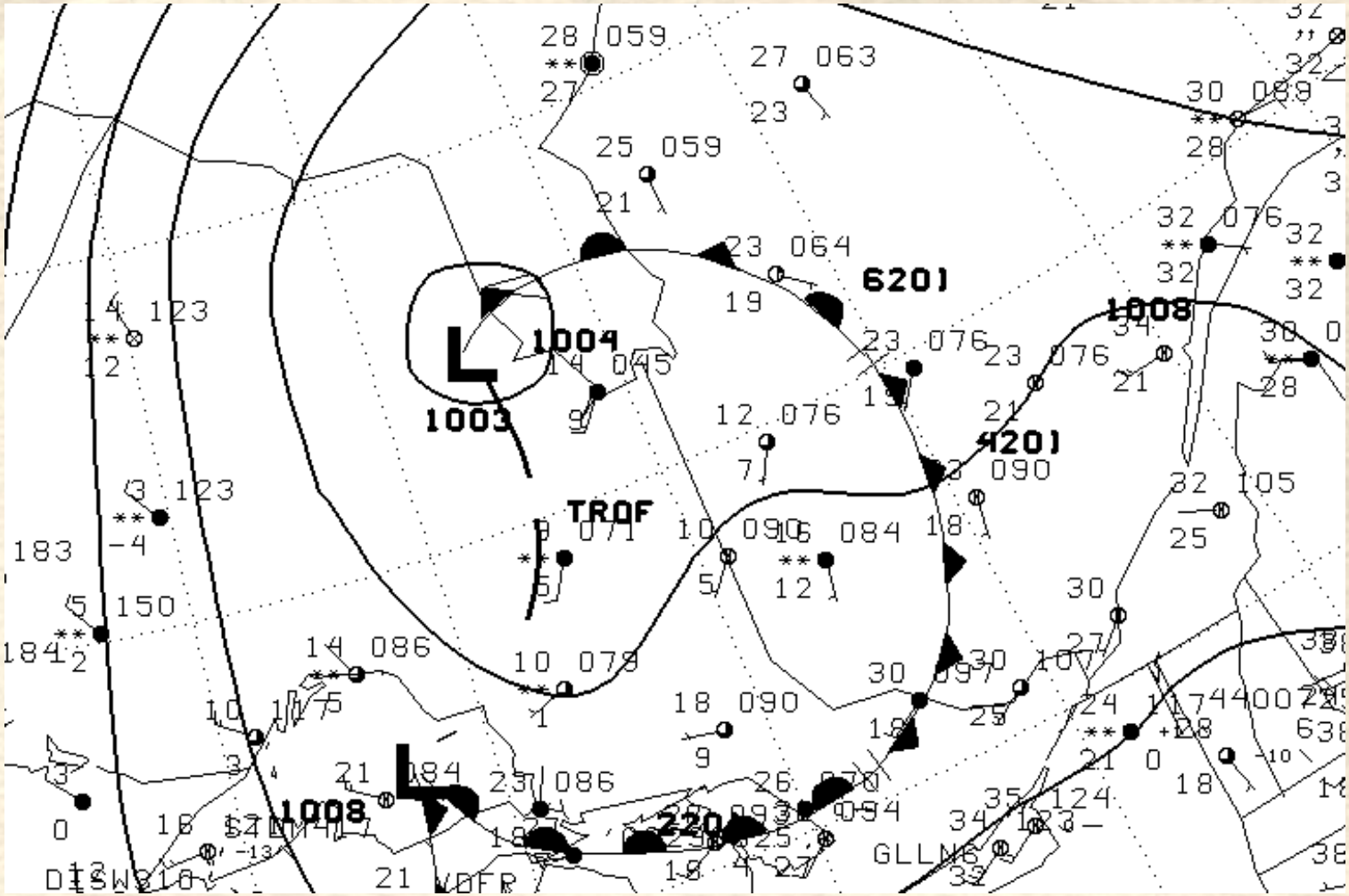
Types of Fronts

- Instant Occlusions
  - Formation of an occluded front usually from a surface trough embedded in cold air
  - Normally develops as a short-wave progresses over an expansive region of cold stable air.
  - The short-wave forces a surface trough and low pressure center to form in the cold air, transitioning shortly thereafter into an occluded front.
  - With the instant occlusion, there is no merger of warm and cold fronts.
  - Somewhat warmer air aloft is lifted by jet dynamics associated with the short wave and cloudiness and precipitation develop.

Instant occlusion



Instant occlusion



Types of Fronts

- Often, instant occlusions form when a surface trough and low pressure system deeply embedded in cold stable air approach a baroclinic frontal zone. As the low moves pole-ward of this baroclinic zone, the trough trailing south from the low intersects the surface front, forming a triple point along the baroclinic zone. The trough becomes an “instant occlusion” between the low and the triple point.

Types of Fronts

- Characteristics of “classic” occluded fronts.
  - Temperature structure varies
  - Winds veer with passage
  - Winds ahead typically east or southeast, behind typically west or southwest
  - Found in or near low pressure trough within thickness ridging
  - **Structure can vary greatly!!!**
    - » Vertical motion, latent heat release and other diabatic effects, as well as terrain can substantially affect the thermal pattern associated with the occlusion

Types of Fronts

- Jet relationships associated with classic "text book" occlusions.
  - Takes on one of two configurations: Type "A" or "B"

Types of Fronts

- Type “A”
  - » Result of meridional trough cyclogenesis (i.e., a trough roughly exhibiting a neutral or slight positive tilt.)
  - » Occurs along east coast U.S. and western Atlantic
  - » Begins formation at surface
  - » Primary driver is low-level thermal advection

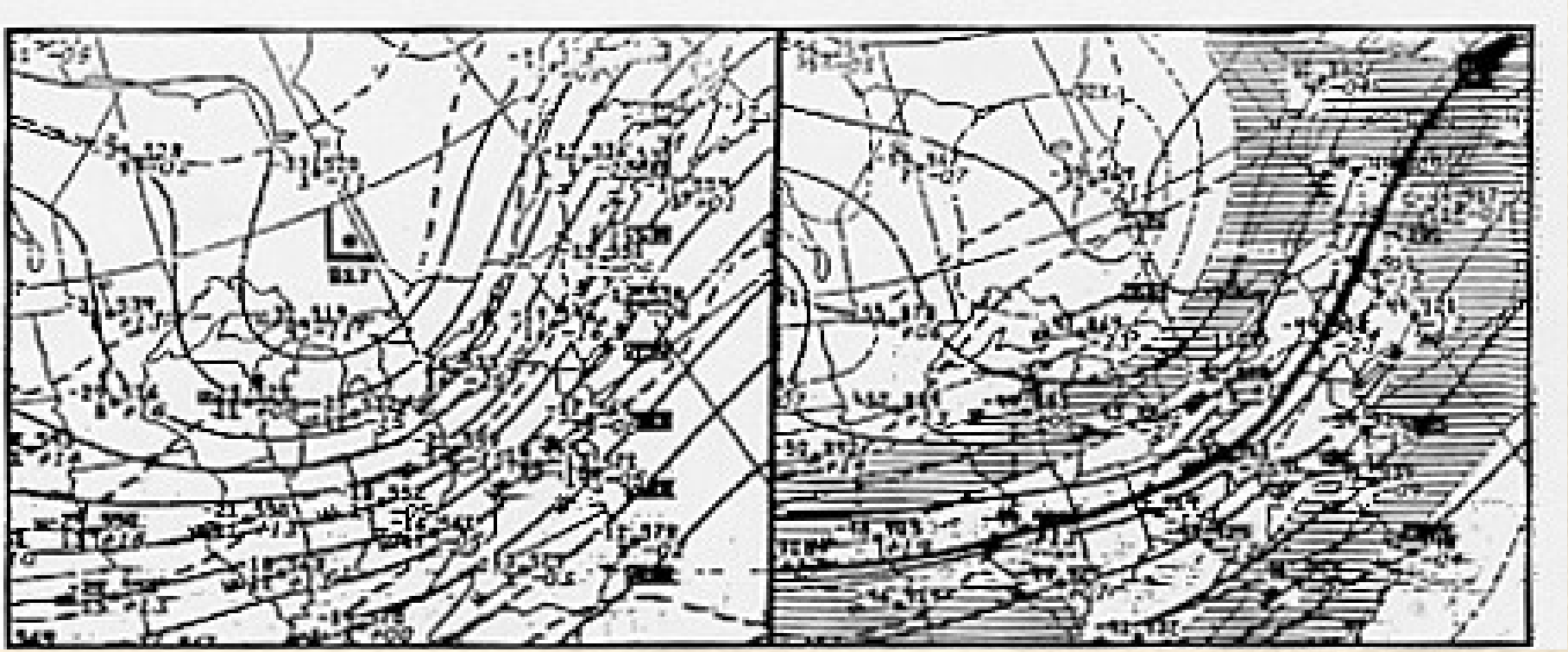
Types of Fronts

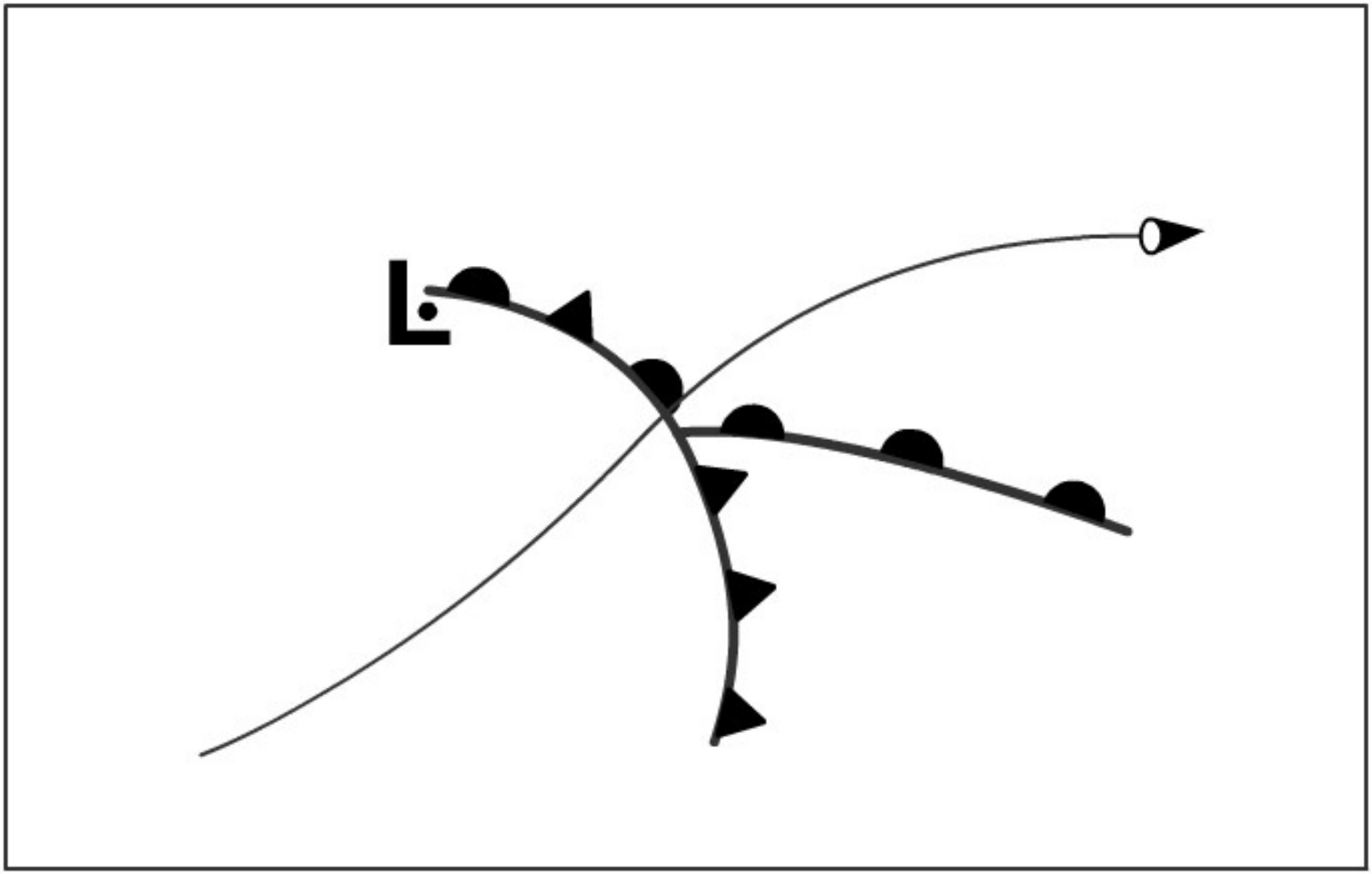
» Jet crosses occlusion as well defined band of strong winds

Jet axis remains uniform

Axis crosses occlusion at or just north of triple point when over water, but this statement often does not work well over land where terrain and large static stability of polar air masses may alter frontal positions.

Type "A" System On 500mb And 300mb Charts





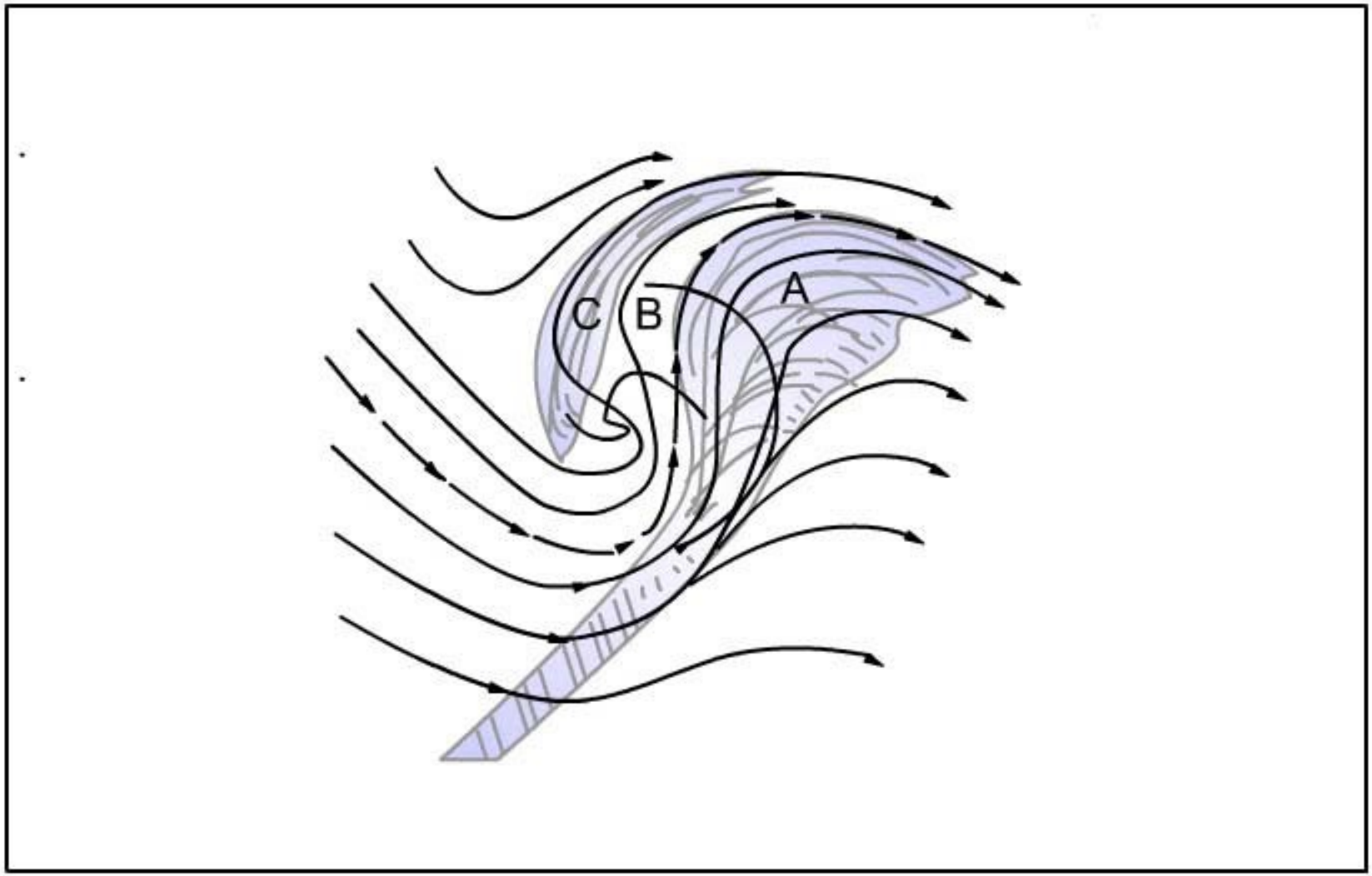
Types of Fronts

» Satellite indications

(1) Baroclinic Zone Cirrus well developed, remains on -n side of axis

(2) Vorticity Comma Cloud visible on +n side of axis

(3) Deformation Zone Cirrus space, with definite distinction between this cirrus and BC Cirrus

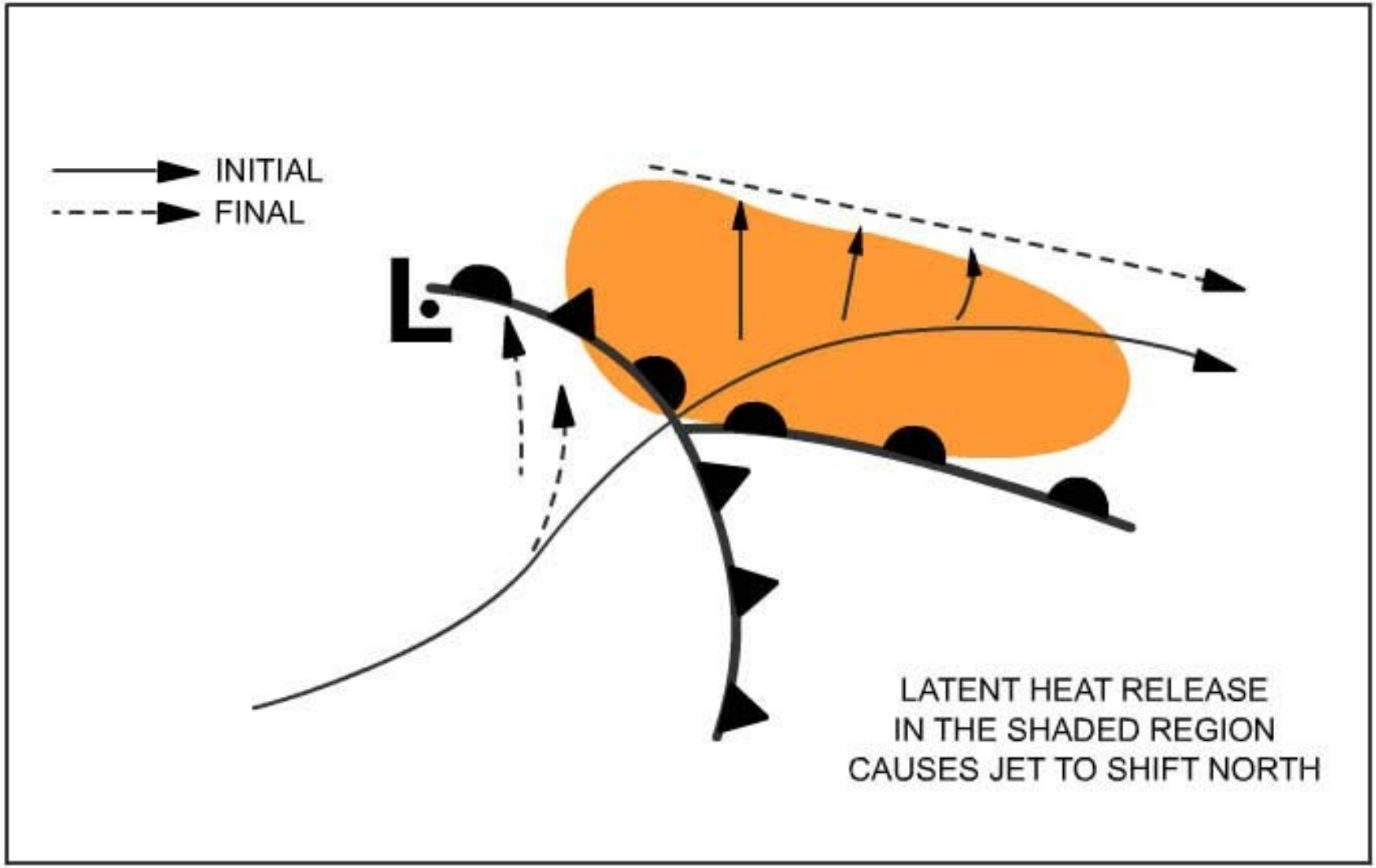

C
B
A

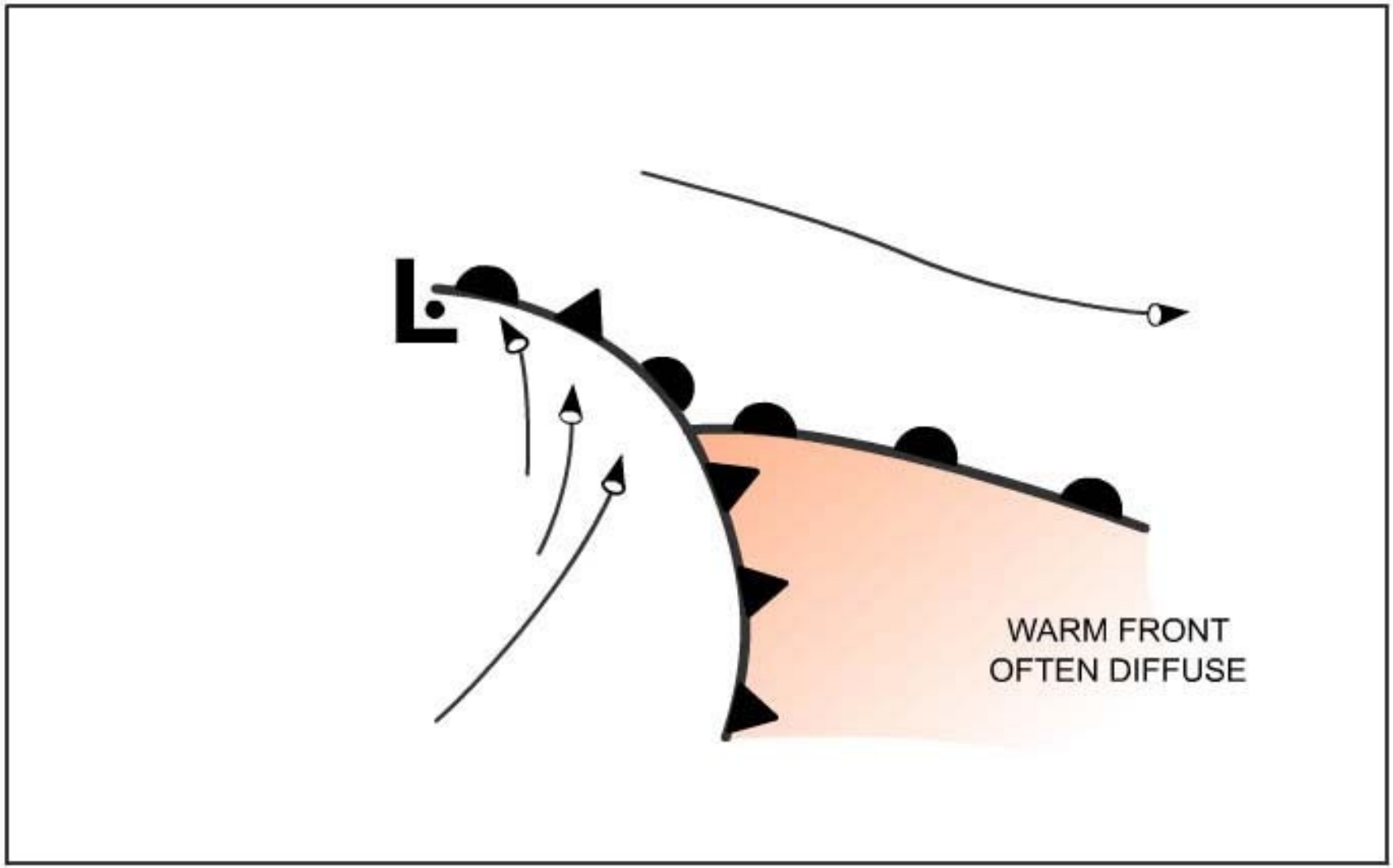
Types of Fronts

- Type “B”
  - » Forms in response to massive divergence from southern and northern branches of jet stream. This divergence is indicated by differential vorticity advection associated with upper-level short-wave disturbance which becomes negatively-tilted.
  - » Product of Split Flow
  - » Most prevalent form of cyclogenesis over central U.S. east of Rockies
  - » Formation begins in mid-levels
  - » Jet does not cross occlusion intact
  - » Latent heat release within overrunning precipitation warms baroclinic region beneath jet

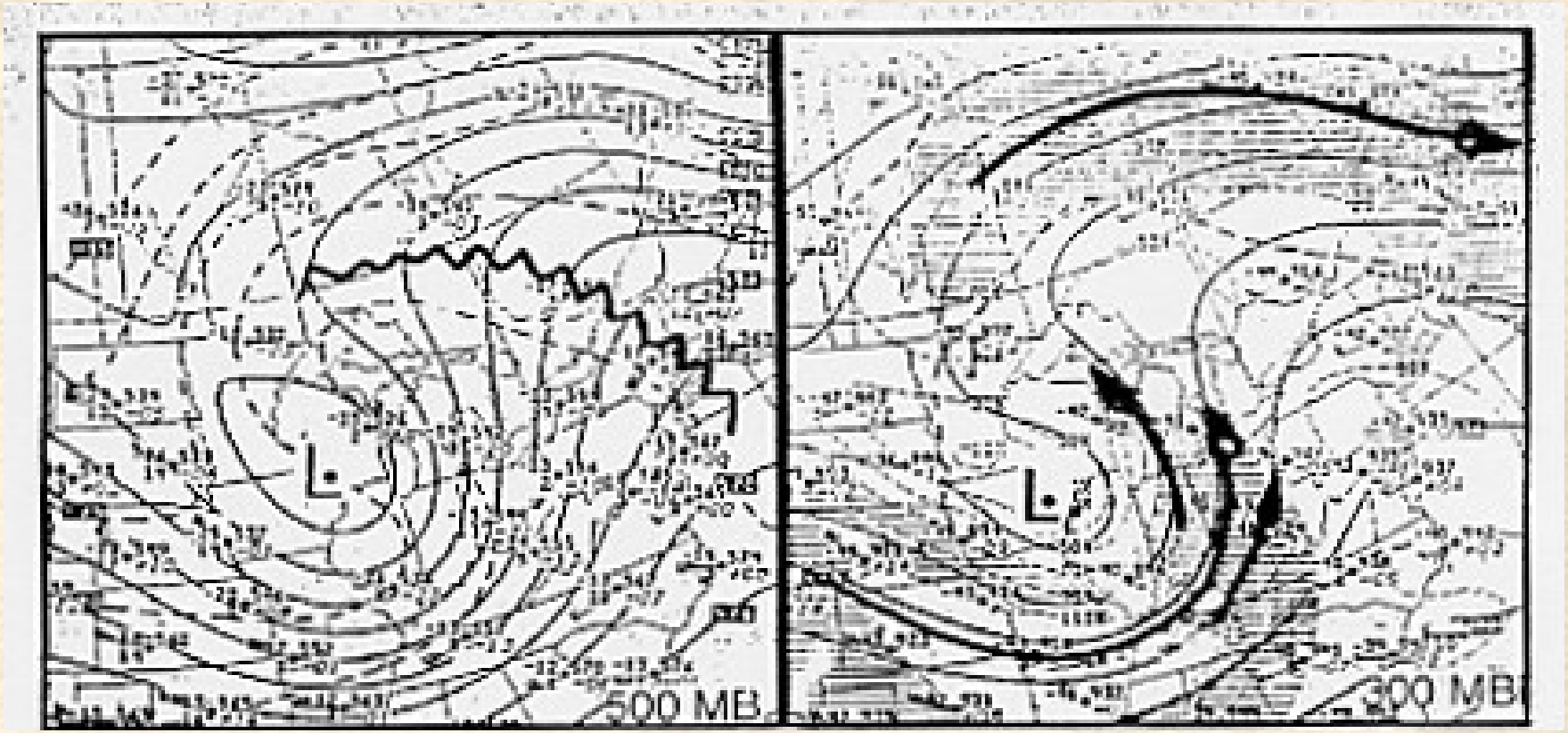
Types of Fronts

- Latent Heat Release In A Baroclinic Low
- Strongest baroclinicity shifts poleward
- Jet wraps in toward upper-level low, new segment forms farther poleward
- Intense NW ridge develops in upper levels ahead of system, wrapping westward around low
- Trough becomes negatively-tilted
- A well-defined closed upper low forms within the trough.


INITIAL
FINAL
L
LATENT HEAT RELEASE
IN THE SHADED REGION
CAUSES JET TO SHIFT NORTH


WARM FRONT
OFTEN DIFFUSE

Type "B" System On 500mb and 300mb Chart



Types of Fronts

» Satellite Indications

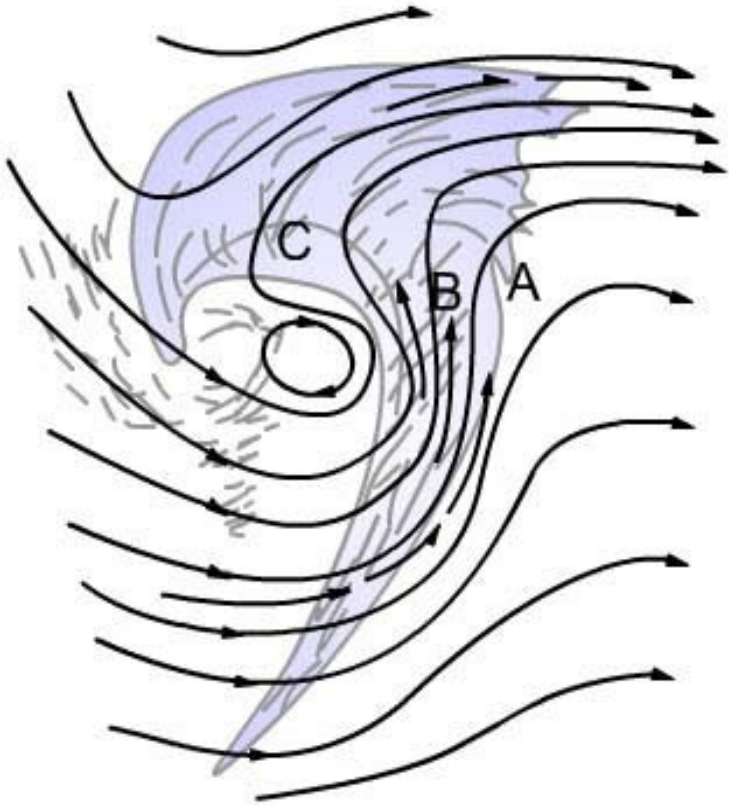
(1) Baroclinic Zone Cirrus well developed and remains on -n side of axis

(2) Where jet fans out in pronounced difluence, Baroclinic Zone Cirrus has less defined border

(3) Vorticity Comma Cloud occasionally visible behind Baroclinic and Deformation Zone Cirrus cloud shields

(4) Deformation Zone Cirrus widespread, well developed and merged with BZ Cirrus

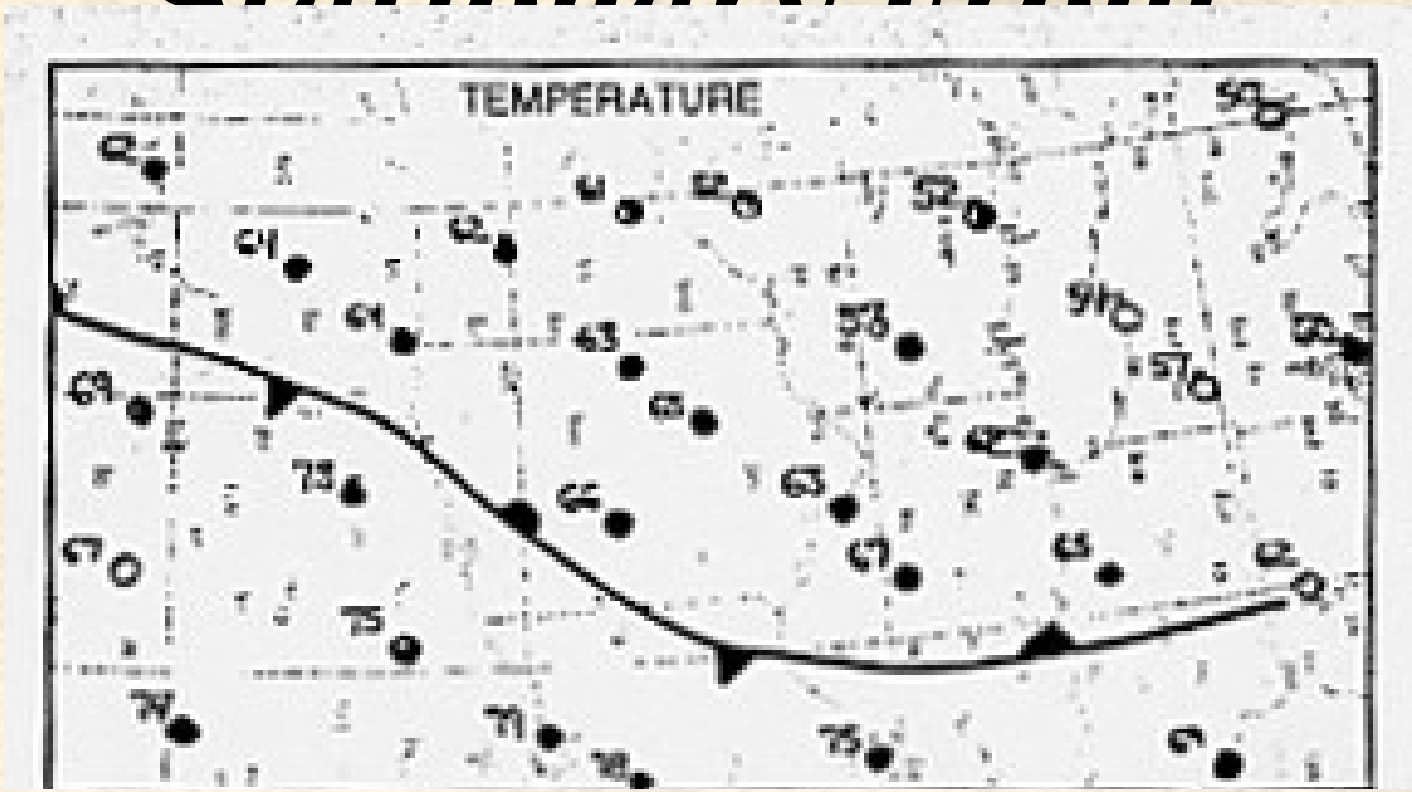
(5) Surface features (fronts) more difficult to locate due to lack of separation of cirrus shields


C
B
A

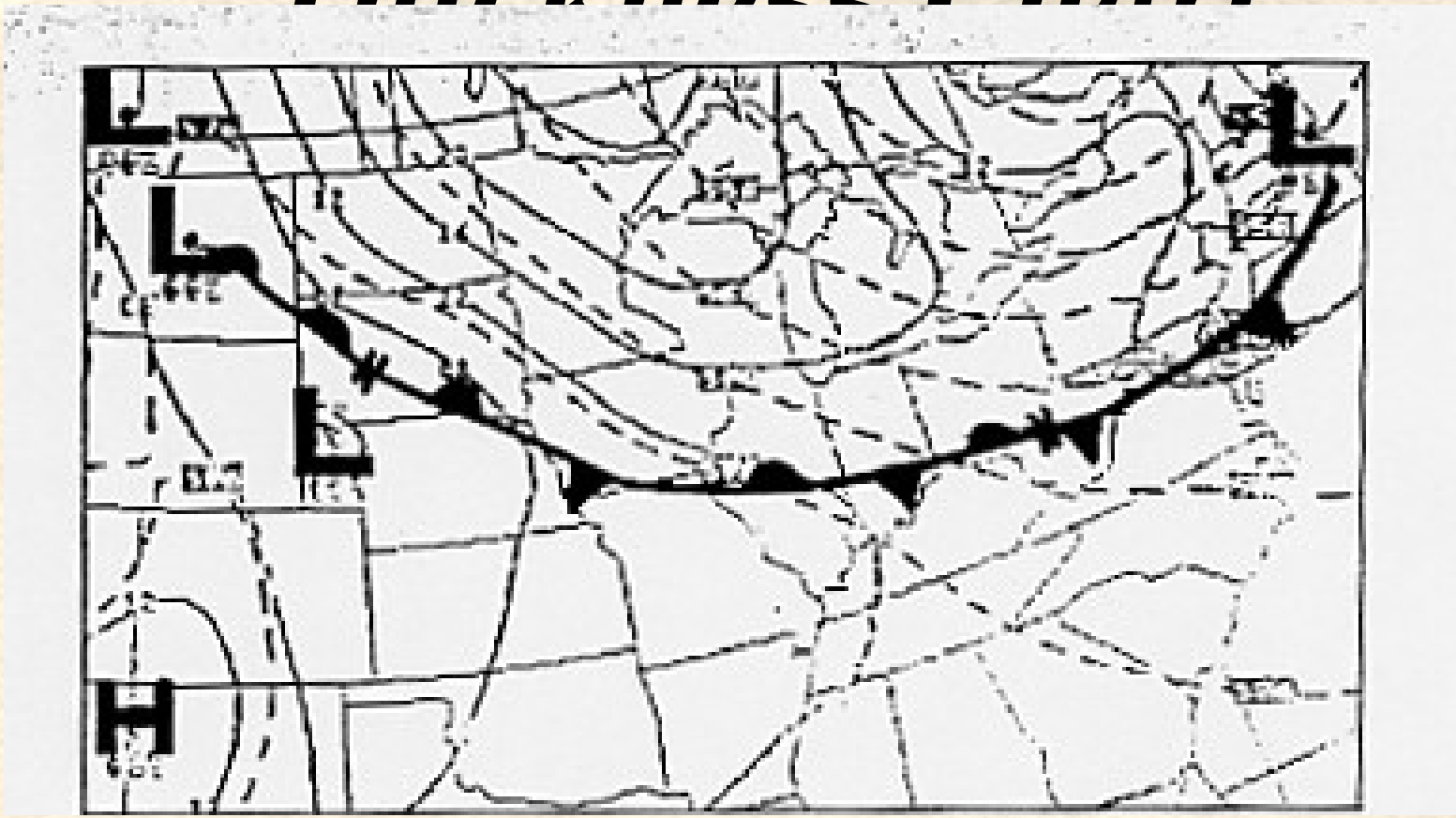
Types of Fronts

- Stationary Front
  - Exhibits little or no movement.
  - Structure
    - Horizontal
      - Temperature discontinuity exists across frontal surface
      - Surface front will be found on warm side of transition zone.
      - Generally lies in a frontal trough.
      - Winds aloft are often nearly parallel to front, thus little temperature advection.

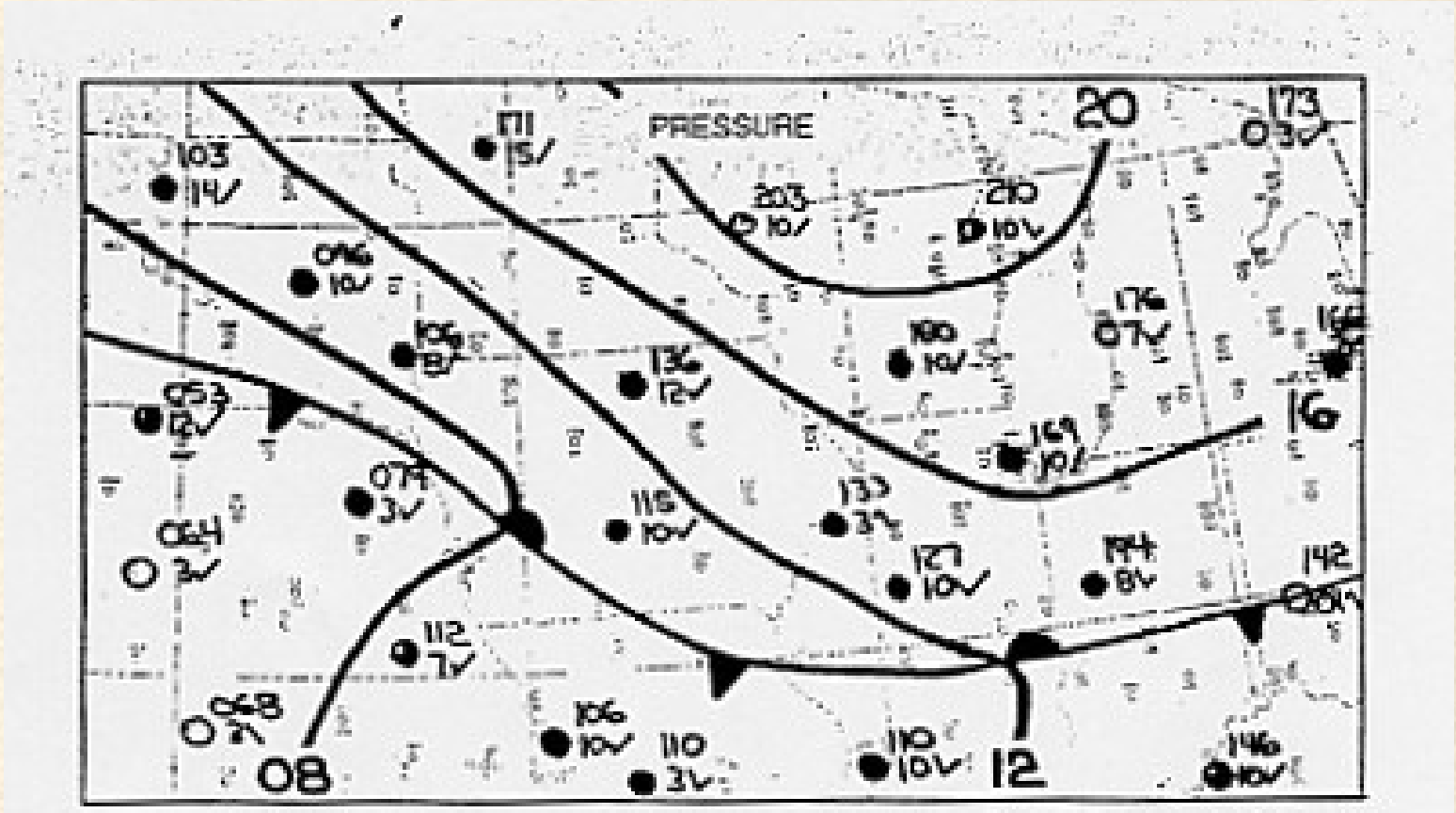
Temperature Discontinuity Across a Stationary Front



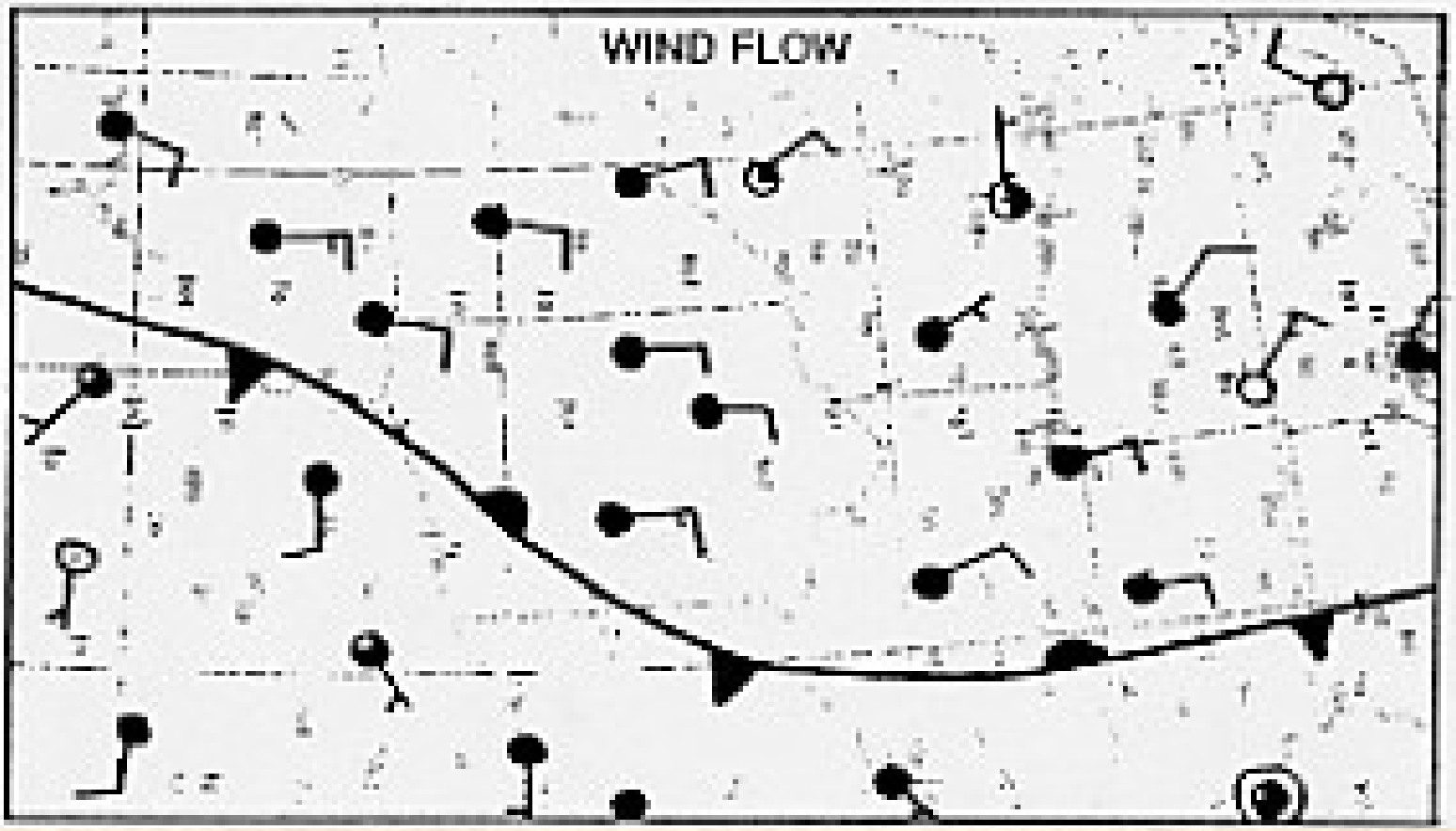
Stationary Frontal Location on a Thickness Chart

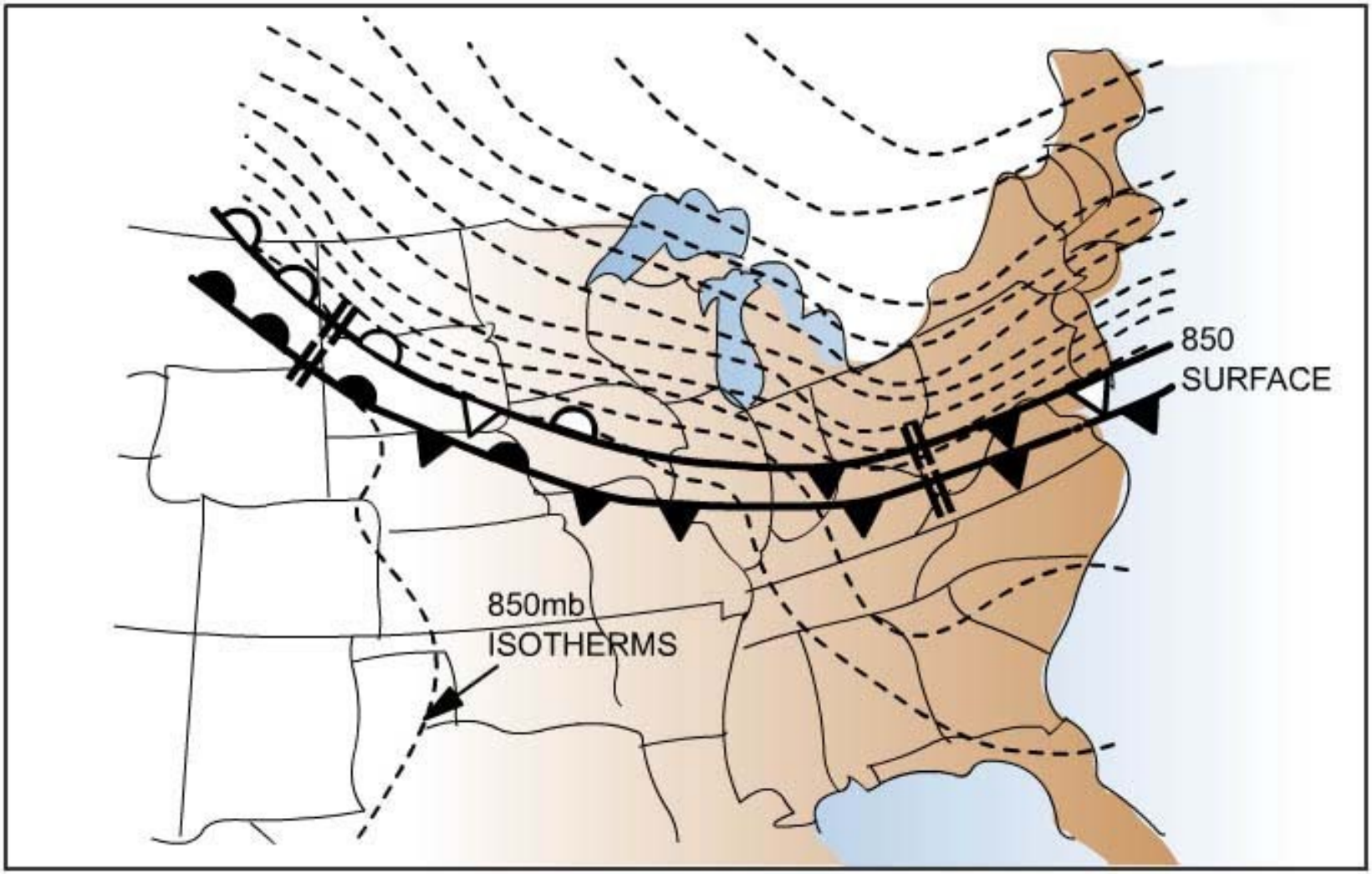


Pressure Field around a Stationary Front



Wind Field Around a Stationary Front

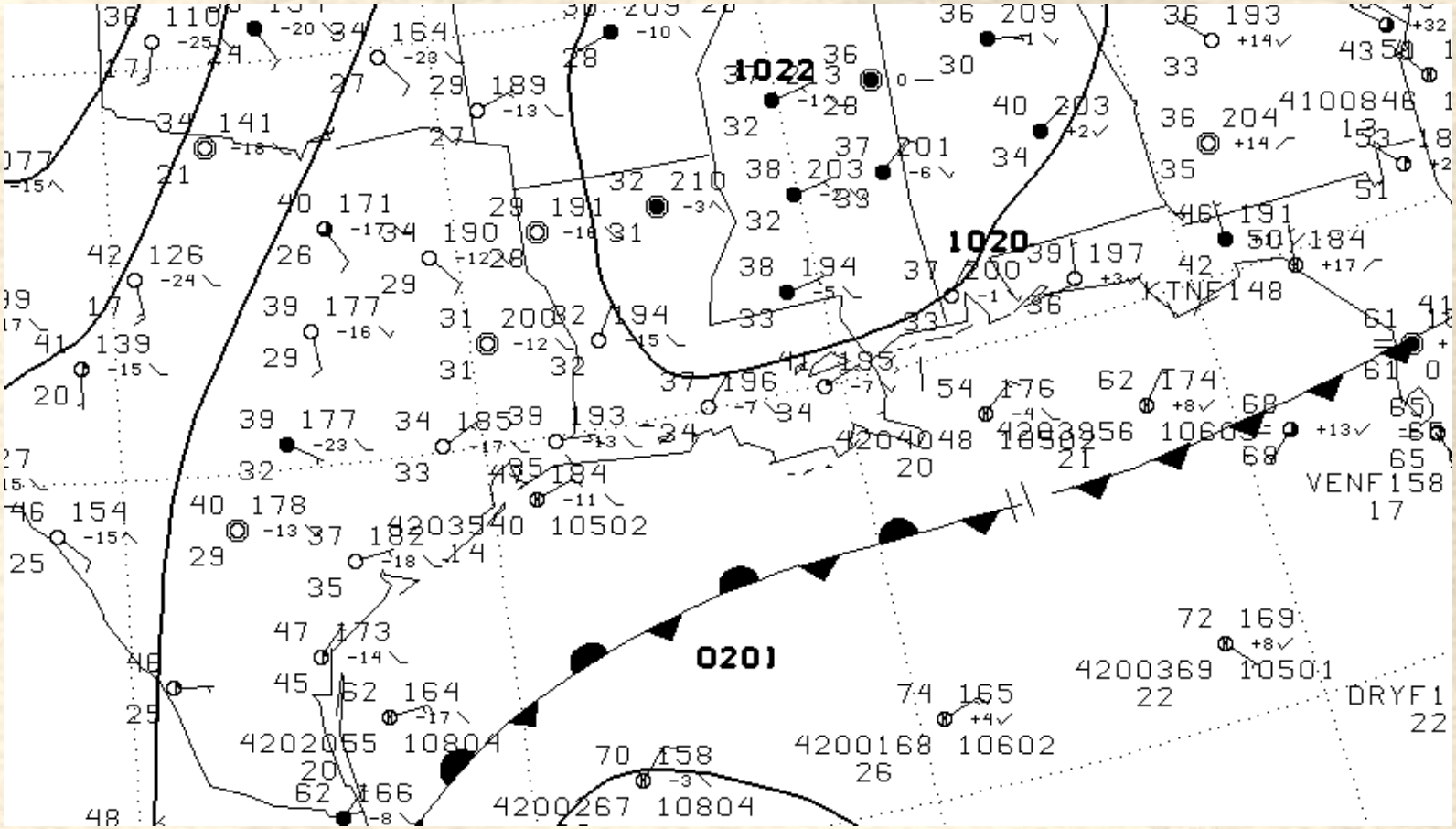



850
SURFACE
850mb
ISOTHERMS

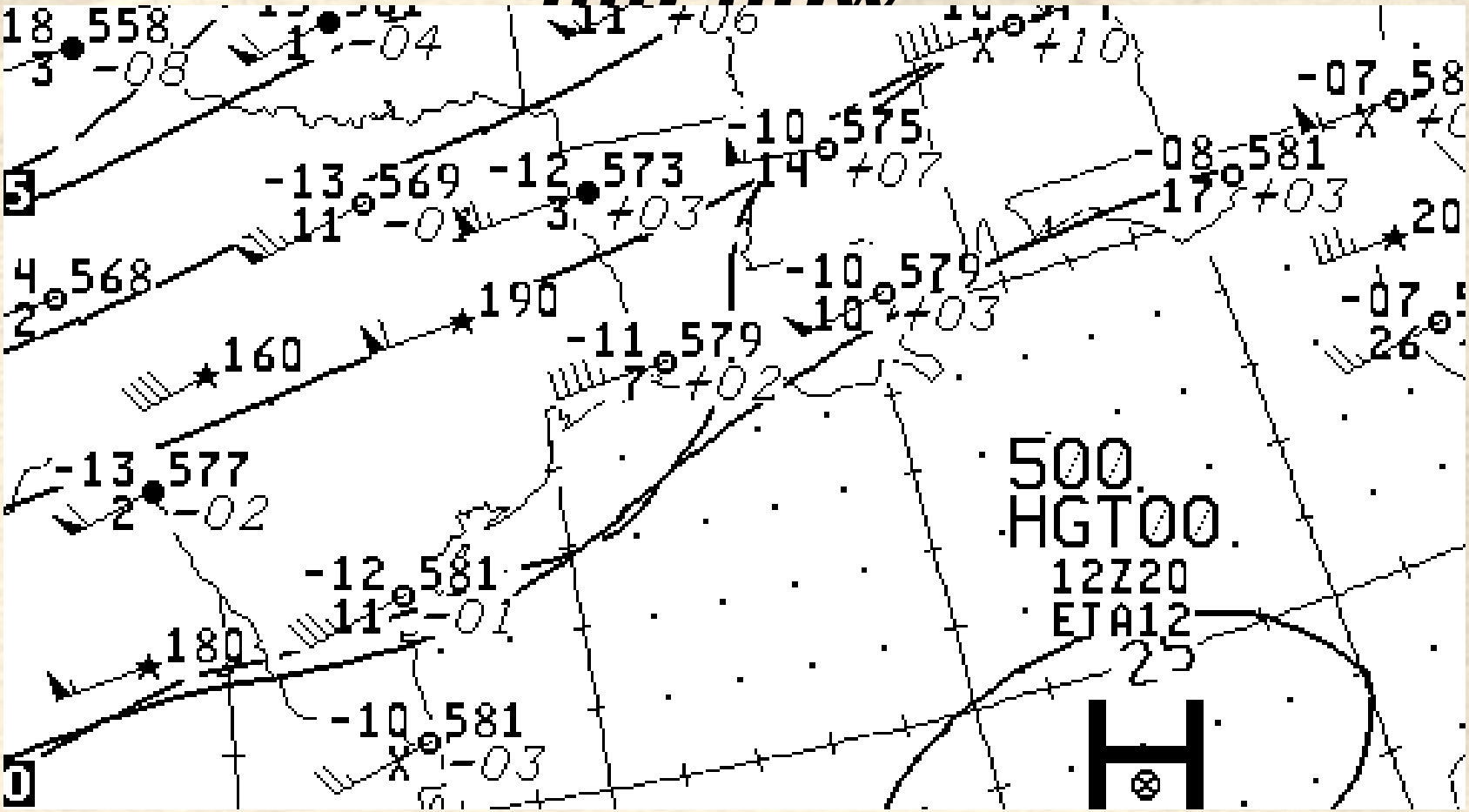
Types of Fronts

- Stationary fronts can be either active or passive, depending on their position to the upper-level wave pattern and jet stream.
- Active stationary fronts often have weather similar to active warm fronts due to strengthening warm advection over-running ahead of an apporaching shortwave trough. Many times, these fronts are about to become warm fronts.
- With passive stationary fronts, lift (if any) tends to be concentrated near the surface front due to lack of a significant shortwave and associated divergence / thermal advection patterns.

Stationary front at the SFC….



...parallel to upper level 500 mb flow

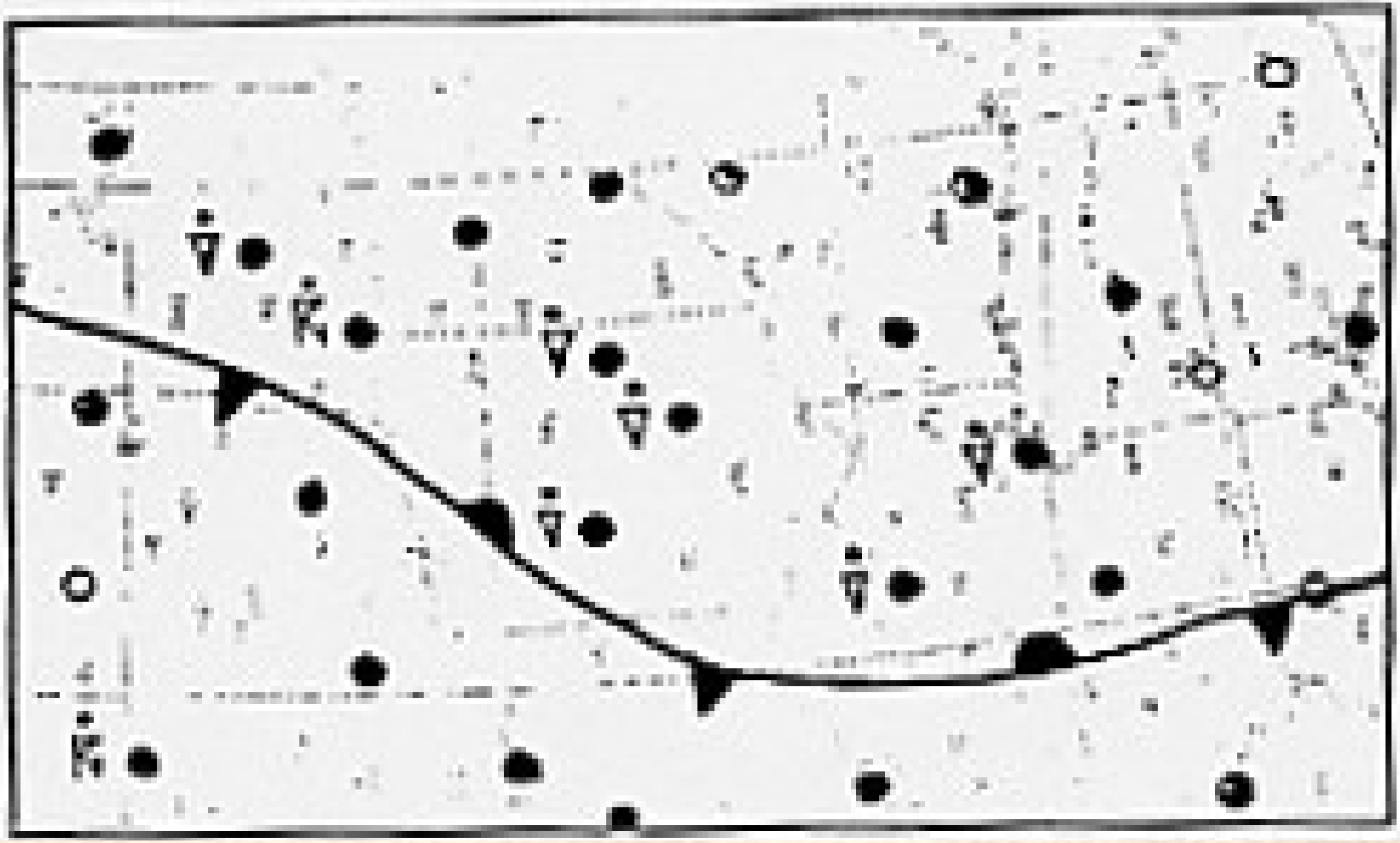


Types of Fronts

- Vertical
  - Frontal surface slopes over colder air mass.
  - Frontal surface is identified as warm side of transition zone.
  - A RAOB sounding will show light winds in transition zone of passive stationary fronts indicating weak temperature advection.

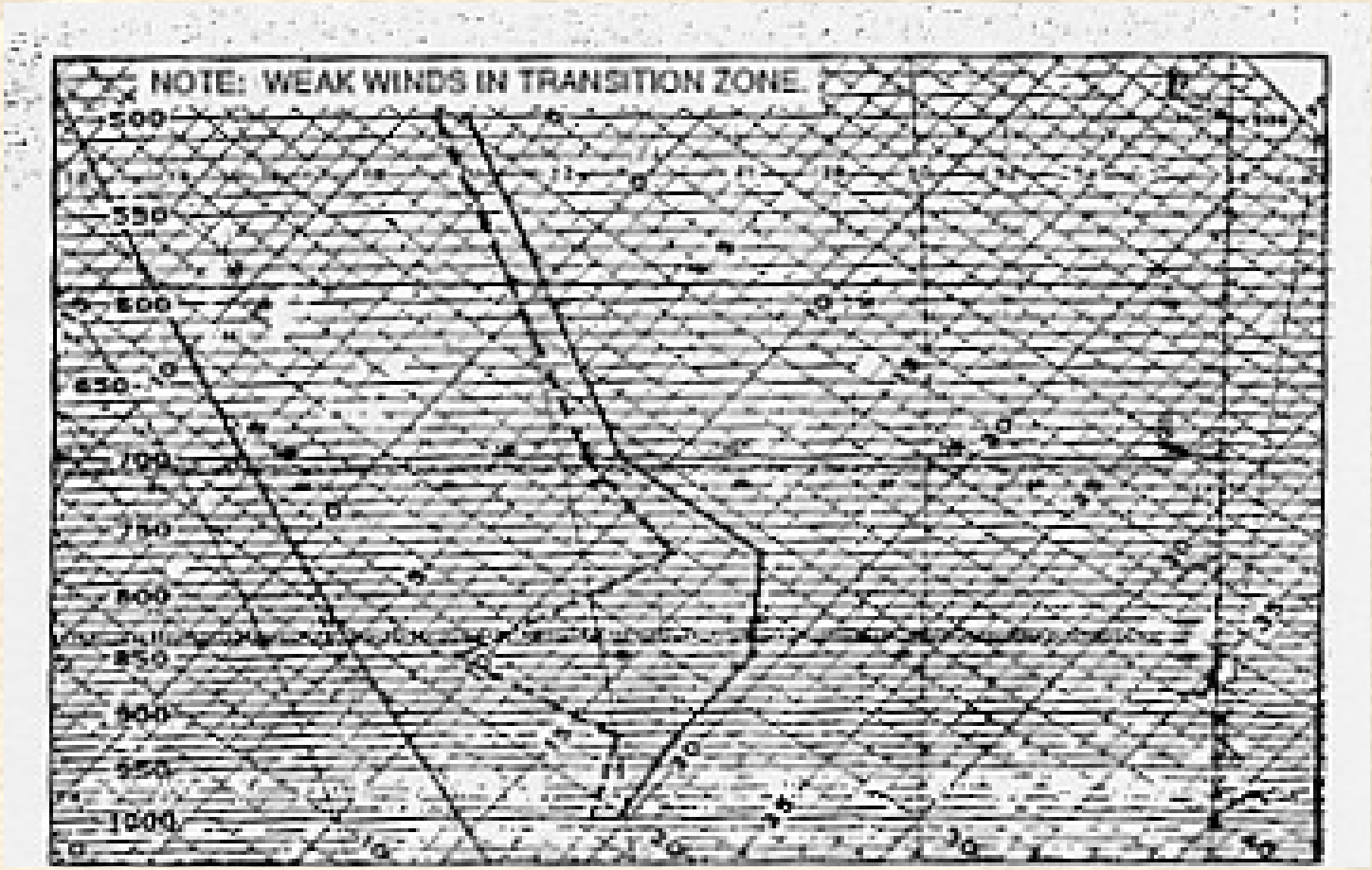
Types of Fronts

- Associated Weather
  - Stratiform clouds and precipitation is generally on cold side.
  - Cumuliform clouds and precipitation can occur on either side of front, depending on stability.



Air Mass Stability and Frontal Weather

- Stability of the warmer air mass determines what type clouds will occur.
- Best tool for determining stability of air mass is Skew-T/Log P diagram and computer-derived stability indices from atmospheric soundings.
- Consider type air mass when using weather and clouds.


NOTE: WEAK WINDS IN TRANSITION ZONE.
500
550
600
650
700
750
800
850
900
950
1000

- APPLICATION: ST Review Exercise 2
- EVALUATION:
  - Informal: Appraisal
  - Formal: Written Test